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David J. Kossak
Michigan Technological University

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PARTICIPANT IMPACTS FROM A PARTICIPATORY WATER MODELING WORKSHOP IN THE SONORA RIVER BASIN, MEXICO

By:

David J. Kossak

A THESIS

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This thesis, "Participant Impacts from a Participatory Water Modeling Workshop In Sonora Mexico," is hereby approved in partial fulfillment of the requirements of the Degree of MASTER OF SCIENCE in Forestry.

School of Forest Resources and Environmental Science

Thesis Advisor:	*Dr. Kathleen E. Halvorsen*
Committee Member:	*Dr. Alex S. Mayer*
Committee Member:	*Dr. Paul V. Doskey.*
School Dean:	*Dr. Terry Sharik*

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Abstract

Much of the research in the field of participatory modeling (PM) has focused on the developed world. Few cases are focused on developing regions, and even fewer on Latin American developing countries. The work that has been done in Latin America has often involved water management, often specifically involving water users, and has not focused on the decision making stage of the policy cycle. Little work has been done to measure the effect PM may have on the perceptions and beliefs of decision makers. In fact, throughout the field of PM, very few attempts have been made to quantitatively measure changes in participant beliefs and perceptions following participation. Of the very few exceptions, none have attempted to measure the long-term change in perceptions and beliefs. This research fills that gap.

As part of a participatory modeling project in Sonora, Mexico, a region with water quantity and quality problems, I measured the change in beliefs among participants about water models: ability to use and understand them, their usefulness, and their accuracy. I also measured changes in beliefs about climate change, and about water quantity problems, specifically the causes, solutions, and impacts. I also assessed participant satisfaction with the process and outputs from the participatory modeling workshops. Participants were from water agencies, academic institutions, NGOs, and independent consulting firms. Results indicated that participant comfort and self-efficacy with water models, their beliefs in the usefulness of water models, and their beliefs about the impact of water quantity problems changed significantly as a result of the workshops. I present my findings and discuss the results.

Chapter 1: Introduction

This chapter provides an overview of my thesis project, and some background information to put the project into context. I begin by introducing the water problems faced in the Sonora River Basin. I then present an introduction to hydrologic and water resource systems modeling, and discuss prior work that identified how much these tools are used in Sonora by water managers. Next I provide a brief overview of participatory modeling (PM), the tool used in this project, followed by an overview of the policy cycle and how participatory modeling fits into this. I finish with a brief introduction to my research questions and approach.

The Sonora River Basin

Sonora is a state in northwestern Mexico, with its capital at Hermosillo. It has a mostly semi-arid to arid climate with limited water resources (INEGI 1993). Sonora regularly experiences drought and monsoon-type heavy rainfall (Sheppard et al. 2002). Decision makers have had to impose periodic water rationing during extended droughts (Pineda 2006). The state has several important river systems supplying drinking water (SEGOB 2014). The Sonora River Basin (SRB) is the largest. Water is being removed from the SRB at an unsustainable rate, with the largest portion used in Hermosillo (Moreno Vazquez 2006). Waterborne illness is a problem due in large part to inadequately processed wastewater (Robles-Morua et al. 2009, 2011). Adding to these problems, Hermosillo is growing rapidly at over 1.5% per year, increasing water demand

(CONAPO 2008). In addition, climate change impacts are expected to increase water resource management challenges (Browning-Aiken 2007).

As a result, SRB faces many problems with water management challenges (Moreno-Vazquez 2006) including a lack infrastructure to moderate extremes in water availability (Ellis et al. 2007). The primary agency responsible for surface water management is the Mexican National Water Commission (CONAGUA). Other Sonoran water management agencies include: the Comisión Estatal de Aguas (CEA), the state water management agency; Agua de Hermosillo, the Hermosillo municipal water management agency; and various watershed councils that provide advice on managing individual watersheds (Aparicio 2010). These councils are often hindered by a lack of funding (Tortajada and Contreras-Moreno 2005, Pineda 2006, Robles-Morua et al. 2009). Other agencies with more minor water management responsibilities include La Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora (CEDES) which is the commission for ecological health and sustainable development in Sonora, Secretaría de Agricultura, Ganadería, Recursos Hidráulicos, Pesca y Acuacultura (SAGARHPA) which is the Sonoran state agriculture, ground water, fish, and aquiculture agency; the Secretaría de Agricultura, Ganadería, Desarollo Rural, Pesca, y Alimentacion (SAGARPA) which is the federal agriculture, farming, rural development, fish, and food agency; the Secretaría de Desarollo Social (SEDESOL) which is the federal welfare agency, and La Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (the federal environmental agency), among others (Aparicio 2010).

Climate change is expected to significantly impact Sonora (Magana and Conde 2000). Water is expected to become scarcer as precipitation becomes more variable (Covich 2009). Higher temperatures will lead to a reduction in water availability due to greater rates of evapotranspiration (Carpenter et al. 1992, Covich 2009). Expected population growth is characteristic of many other arid regions (CONAPO 2008, Vorosmarty et al. 2000). It will likely increase urban development creating higher water demand in dense population centers. This could lead to urban water scarcity which could cause both socioeconomic and environmental problems (Covich 2009, Limberg et al. 2010).

Hydrologic and water resource systems models

This section briefly describes water models, specifically the hydrologic model system, HEC HMS, and the modeling software, STELLA, both of which were used in this project. First, I present information regarding hydrologic models and HEC HMS. Then, I describe STELLA and water resource systems modeling.

Systems dynamics is at the heart of both of these model types. System dynamics focuses on changes and feedback loops within a bounded system (Forrester 1958, 1961; Lane 1995). Systems that appear to fairly linear can actually be very complex (Lane 1995). Hydrologic models and water resource systems models are specific types of systems dynamics models. Models relate inputs to outputs (Feldman 2000). Hydrologic models connect inflowing water or precipitation, to outflows in a hydrologic system (Feldman 2000).

Sandoval (2004) concluded that water managers in Mexico need a better understanding of hydrology. Hydrologic models are useful water management tools to conceptualize the hydrology of a region (Kepner and Semmens 2004). Few agencies or other groups in Sonora use water models on a regular basis (Brenna 2012). One type of hydrologic modeling software is the Hydrologic Modeling System (HEC HMS), designed in the early 1990s by the United States Army Corps of Engineers-Hydrologic Engineering Center. The software has a graphical user interface, and many diverse capabilities that make it very a useful tool (Scharffenberg and Fleming 2010).

Water resource systems are "a set of water resource elements linked by interrelationships into a purposeful whole" (Vortruba 1988, p.38). They can include both natural and made-made components (Vortruba 1988). STELLA is modeling software that can be used to model water resource systems (Gaddis et al. 2010, Langsdale et al. 2009). STELLA incorporates visual representations of systems using stock and flow diagrams and models can be customized with optional buttons, sliders, etc. (STELLA product support page). The user-interface is ideal for use in participatory modeling, especially for those with little or no modeling experience (Langsdale et al. 2009).

Participatory modeling

In this section I present an overview of what PM is, how it is used, and why it is useful. PM is a method of model development that helps participants and modelers/researchers understand each other better with respect to their position on the issue (Cabrera et al. 2008). Often, this system is a natural system such as watershed or water resource system (Dietz et al. 2004, Korfmacher 2001, Smith-Korfmacher 1998, Voinov and Gaddis 2008). Participatory modeling creates a mix of values and data that produces models that can be used to make natural resource management decisions (Barreteau et al. 2007; Beall and Zeoli, 2008; Jones et al. 2008) and is becoming a common means to assess tradeoffs related to policy decision making (Kelly et al. 2013; Kragt et al. 2011).

PM can help ease acceptance of data or management recommendations derived from models, by building trust in a model. Watershed modeling usually requires public funding and modeling choices affect information (quality and certainty) used in decision-making (Korfmacher 2001). Participants make their own unique contributions. Their values and knowledge should be included. Examples include cost/benefit perceptions of natural resources by different groups and land-use practices and trends observed by individuals (Korfmacher 2001). Participants are more likely to support and promote a decision that they have been directly involved in. If participants are able to see what data is used to produce a watershed model, they may understand the outcomes better and accept them more readily (Jones et al. 2008, Korfmacher 2001). People who will be affected by a management decision will value being included in building a model of the system that they are a part of (Korfmacher 2001).

PM can change group behavior and dynamics. Participants may become better informed about an issue and as a result work together better after a PM workshop (Jones et al. 2008). They may come to understand each other better including their respective strengths, weaknesses, beliefs, and expertise. Participants can also develop a common understanding of each other's concerns, allowing them to better accommodate each other's values (Jones et al. 2008).

PM is a broad field that includes participants at different decision making stages and involves them in model development in different ways and to different levels of intensity (Beall and Ford 2007, Hare 2011). They are not usually required to be modeling experts, or even experts in the field (Barreteau et al. 2007, Jones et al. 2008, Voinov and Gaddis 2008, Tsouvalis and Waterton, 2012). Robles-Morua et al. (2014) summarize various descriptions of participant involvement into four PM approaches ranging from inclusion in initial model framing and development to model presentation only at the end of the process when all major modeling decisions have been completed. Participants can be resource users (Cabrera et al. 2008, D'Aquinto et al. 2002, Korfmacher 2001) or decision makers (Atunes et al. 2006, Jones et al. 2008, Yearley et al. 2003). Voinov and Gaddis (2008) advocate building participant trust in the model during the process. Many other successful PM work has been carried out where participant trust and comfort with the model was observed by the researchers (Cockerill et al. 2004, Van den Belt 2004, Robles-Morua et al. 2014), or participants believed the model was useful (Cockerill et al. 2004, Bots et al. 2008, Dietz 2004).

Participatory modeling is a versatile tool for resource planners and managers, especially concerning water management. Sandoval (2004) presented a project that included the development of hydrodynamic models and the conducting of hydrogeological studies, while simultaneously promoting a water user participation structure where users could help agencies implement better management strategies. Langsdale et al. (2009) presented participatory modeling of how climate change might affect the Okanagan River Basin in British Columbia, Canada. Haapasaari et al. (2013) described PM research on perceptions about the Baltic herring fishery. Pierce et al. (2012) presented work where multiple interest groups vie for control over unique geothermal water resources that can provide energy and support unique ecosystems, yet are also an integral part of a larger watershed system. Castelleti and Soncini-Sessa, (2005) described work concerning management of a transboundary lake, specifically lake water level and outflow. Barreteau et al. (2001) presented PM research regarding the poor performance of irrigation systems in the Senegal River Valley. Luijten et al. (2003) used watershed modeling to give local water users a tool in negotiations for use rights. Metcalf et al. (2010) presented work regarding conflicting use and values in a flood plain. Gaddis et al. (2007) presented research using PM to model nitrogen from non-point sources, and Gaddis et al. (2010) described a case where phosphorus loads in a watershed exceed maximum allowed levels. Through PM, possible solutions to often difficult problems can be explored in a group setting. Van Dam et al. (2013) used PM to better understand the relationship between hydrology, the function of ecosystems, and socioeconomics in wetlands. Common to all of these PM cases is an interaction between water users and water systems where there is some problem or conflict that is difficult to resolve otherwise.

Participatory modeling and the policy cycle

It is important to understand the function of PM within the policy cycle. Many researchers have identified five policy making stages: agenda setting, policy formulation, decision making, policy implementation, and policy evaluation (Howlett et al. 2009; Lasswell 1971; Parag 2006, 2008; Sobeck 2003). Anyone can be involved in the first and last stages (Howlett et al. 2009). For the second and fourth stages, individuals with some expertise or interest in the issue are involved (Howlett et al. 2009). For the third stage, only decision makers can be involved. This stage requires the authority to decide on a course of action (Howlett et al. 2009).

PM can be used during any of these stages. It has the ability to facilitate dialogue between policy actors. Policy entrepreneurs use policy windows to put issues on the policy agenda (Howlett 2009, Kingdon 1984). In a sense, PM exercises i.e. the workshops and PM events create policy windows, which can then be use by policy entrepreneurs to move a policy issue or possible solution to a policy problem onto the agenda. The PM process would have to facilitate quite dramatic and sweeping changes in values or beliefs about problems to really be termed a "policy window" (Kingdon 1984).

The second, third, fourth, and fifth stages of the policy cycle, specifically policy formulation, decision making, implementation, and evaluation can also be facilitated by PM. In order to determine the best course of action to take, modeling can be useful to decision makers and policy subsystems as a basis for technical advice (Korfmacher

2001). This can lead to policy formulation, (e.g. Gaddis et al. 2007, 2010). PM can also allow for the comparison of alternative policy strategies and lead to decision making (e.g. Castelleti and Soncini-Sessa 2005). It can also facilitate policy implementation by taking into account what is politically possible (e.g.Voinov and Gaddis 2008) and by increasing political power (Hare et al. 2003, Luijten et al. 2003). Finally, gathering information from water users can inform decision makers about the effectiveness of current policy, a form of policy evaluation (e.g. Knapp et al. 2011).

Research questions and project overview

My research questions for this project were:

1. How will participatory water resource modeling impact participant comfort and self-efficacy with models?
2. Will participants have different beliefs regarding climate change, and regional water-quantity problems (causes, solutions, and impacts) after participating in discussion and PM activities?

The project consisted of three workshops, with participants from water agencies, academics, and representatives from NGOs. The modeling itself was done by the researchers. Participants did not directly create the hydrologic or water resource systems models; however, during each workshop the participants were prompted for their input and were asked to critique the models. Their suggestions were integrated into updated versions of the models for each subsequent workshop. They were asked to analyze the model in terms of the current system: the surface water, groundwater, and water demand parameters included in the model. Participants discussed whether the model inputs were adequate. They were also asked what should be included to model future scenarios, including water supply (inputs) and water demand (outputs).

The workshops were designed to first present information about the components of the models developed, including any updates from previous workshops, and then to teach the participants how to use the models. Finally, the participants were given activities to familiarize themselves with the models and to learn to use the models in various scenarios with different climate, infrastructure, and water use parameters.

Chapter 3: Literature review

In the first section of this chapter, I review literature related to the PM of water systems. I describe examples from the body of PM research that has been conducted in the developed world. I then present the literature from PM cases in the developing world, specifically the work that has been done in Mexico and Latin America. In the second section, I discuss the methods of assessing PM success, published in prior work, starting with projects that do not use any formal method, and progressing through increasingly rigorous methods. For these sections, I present an introduction to the section, and an overview of the relevant literature, followed by a summary of the main findings from each case. Finally, in the last section I will specifically identify the research gaps that my work fills.

Trends within participatory modeling

In the introduction, I presented an overview of what PM is, how it is used, and why it is useful. In this section, I present a review of participatory modeling of water systems. I present an overview of PM that has been implemented in the developed world, followed by a review of findings. Then, I present the PM work that has been done in the developing world and summarize the findings. I emphasize the work that has been done in Mexico and Latin America and identify key trends within all of these cases. I identify the stage within the policy cycle that each case of PM is facilitating.

Participatory modeling has been primarily a tool implemented in the developed world, with only a few examples from developing countries. There has been considerable work in the field of participatory water modeling within the United States e.g. Gaddis et al. (2007) in Maryland, Gaddis et al. (2010) in Vermont, Knapp et al. (2011) in Colorado. There have also been participatory modeling examples from Europe such as the work described by Castelleti and Soncini-Sessa (2005) on the Italy/Switzerland border, by Haapasaari et al. (2013) in the Baltic region, and by Zorilla et al. (2010) in Spain.

Gaddis et al. (2007) found that stakeholders were engaged and responded well to the modeling tools presented. Gaddis et al. (2007) found that participants trusted the model. The recommendations were accepted quite readily, and the researchers had hope following their work that real change would happen. The outcome represented the policy formulation and decision making stages of the policy cycle. Gaddis et al. (2009) presented findings that showed that participants generally were trusting of the models they developed. The participants identified new ways to reduce phosphorus loads in the watershed that were less expensive and more effective than previously thought. The modeling was largely a success and increased dialogue and revealed many new ideas and new information. This too was an example of the policy formulation and decision making stages of the policy cycle. Knapp et al. (2011) found that participants were very willing to supply their local knowledge about rangeland despite misgivings about the technology that the information was being integrated into, and that "knowledge integration" within state-and-transition models was possible. In this case, evaluation of rangeland management strategy and existing sources of data for modeling tools represented the policy evaluation stage.

Castelleti and Soncini-Sessa (2005) outlined steps to reach consensus about flooding around Lake Maggiore on the Italian/Swiss border. Participants were able to reach an agreement about a course of action that will benefit all concerned. The authors showed that the process was successful and that it could be implemented in situations such as these to increase dialogue and discussion and find solutions to management problems. This represented a transition through the policy formulation and decision making stages.

Haapasaari et al. (2013) found that gathering subjective views of participants was a useful PM technique to promote dialogue and to foster policy decision making. Their work evaluated fisheries management (i.e. policy) in the Baltic. Zorilla et al. (2010) in Spain advocated simplification of models in the PM process to facilitate learning. They also suggested that their method of modeling, Bayesian models, were a way to facilitate negotiation and dialogue between participants.

Common to these cases, was an overall goal of reaching an agreement about the best management strategy, i.e. decision making. The impetuous for these projects seems to have been a recognized impasse among interest groups that was holding back effective management of a water resource. All of these examples from the developed world focused on bringing together different pools of knowledge and increasing dialogue between participants. Once a consensus was reached, it was fairly straightforward within these cases to implement the agreed-upon policy.

Research involving PM within the developing world has been less common than in the developed regions of Europe and the United States. Also, while water management case studies are readily found for developed countries, PM in less developed regions often focused on other resource problems such as food production (Hare et al. (2003), or ecosystem or tourism management (Amatya el al. 2010).

This was not true for PM in Latin America, where water management represented the focus for all of the PM projects found in the literature. The work by Amatya et al. (2010) in the Hindu Kush-Karakoram-Himalaya region and the cases presented by Hare et al. (2003) in both Africa and Southeast Asia were examples of PM from developing countries outside of Latin America. The few examples that can be found from Latin America include Knapp et al (1997) and Luijten et al. (2003) from Columbia and Luijten et al. (2003) from Honduras, Sandoval, (2004) from Mexico, and Pierce et al. (2012) from Chile.

Amatya et al. (2010) presented findings from their research in the Hindu-Kush-Karakoram Himalaya region. The project was designed as an international partnership; it worked with interest groups to aid local decision makers, and increased communication between all parties involved. They found that following a series of workshops, communication between researchers and policy makers was improved. Local-level PM created ways to manage tourism in the region. Policy makers were given information to help develop policy. Within the policy cycle, this outcome represented an improvement in the transition from agenda setting to policy formulation within the policy cycle.

Hare et al. (2003) presented a good comparison between usage of PM in the developed versus developing world. Of the four case study countries described, a Swiss PM process was the only one that took place within a developed country. The goal was to develop a solution to the problem of too much drinking water. The problem was not ineffective policy implementation, but rather a lack of a consensus regarding the best management strategy moving forward i.e. ineffective policy decision making.

The second case took place in Mahuwe, Zimbabwe. PM was seen as a means to include villager input in policy formulation. Resource conflicts experienced by the villagers were not being adequately addressed by decision makers. Here, agenda setting and policy formulation were the foci. Case three involves empowering local leaders to obtain better agricultural rights in Ngnith, Senegal. The leaders were otherwise unable to represent the interests of their respective constituencies.

With PM, they were able to communicate with other groups with little negotiating power and discuss political strategies to increase their bargaining position. This time, policy implementation was the problem, due to a lack of political power. Finally, case four focused on Northern Thailand, where the management of a river catchment was complicated by different needs of people living above and below it. The government needed information about potential management choices, and researchers wanted to supply the tools and expertise to model these scenarios. Agenda setting and policy formulation were once again the key failures of the policy cycle. The processes were ongoing at the time of this paper's publication, but the authors nevertheless analyze the policy process aided by PM (two top-down, and two bottom-up), and discuss several factors involved. They also stress the importance of representing all interest groups in the co-design stage of PM.

The themes identified within developing countries in Africa and Asia are also found in PM in Latin America: PM was used to combine power with authority by increasing dialogue or consensus building, especially between resource users and resource management agencies. This was either a problem with agenda setting, or implementation. In these Latin American case studies, better management of the resource by empowering water users was often the goal. Sandoval (2004) advocated an approach to PM where management of the resource is the primary goal of the PM exercise. The paper described the formation of groups of water users that supported government that did not have the power to manage water effectively. Policy implementation was the failure identified here.

Water users can be the best managers when policy is ineffective (Sandoval 2004) yet they lack the authority in some cases to make resource management decisions or control the water resource (Luijten et al. 2003, Pierce et al. 2012). Luijten et al. describe a situation where rural water users used GIS as a bargaining tool in water resource negotiations. Here, as in the case in Zimbabwe from Hare et al. (2003), agenda setting and policy formulation were the foci. Pierce et al. (2012) show where increased dialogue between different user groups leading to better understanding of the many aspects of water systems, including user perceptions, can create better tools for water managers to use. Their work aids in policy formulation and implementation.

Throughout all of the cases presented from the developing world, agenda setting, and policy implementation were the most common problems. Policy formulation was also frequently an accompanying issue. When compared to the cases from the developed world, PM in the developing world does not address decision making or policy evaluation as the primary roadblock to movement through the policy cycle.

An earlier component of the project that my work was a part of, presented by Robles-Morua et al. (2014), represents a case where increasing dialogue between water users and water managers or empowering water users i.e. agenda setting or policy implementation, were not the foci of the PM exercise. The authors conducted a participatory modeling workshop in Sonora, Mexico. Participants consisted of decision makers that were in a water management position and academics interested in water management or water resources. The authors assessed participant beliefs about the Sonora River Basin and perceptions of the workshop and the hydrologic and water quality models that they produced through the use of pre-and-post surveys.

The researchers found that beliefs about the problems with water quality in the Sonora River Basin changed from the pre-survey to the post-survey, but beliefs about water quantity problems did not. Participants also evaluated the workshop highly and agreed that the presented models could be useful in the future. Before the workshop, policy makers lacked consensus on what the water problems are or how to manage the water effectively (Robles-Morua et al. 2014). After the workshop, participants agreed that there were water quality problems in the River Basin. This represents another case where agenda setting seems to be the focus of the PM, however, focusing on decision makers, as opposed to water users which are part of the policy universe or policy subsystem, represents a move away from a PM strategy that identifies failures within the policy cycle at the points where the policy universe or policy subsystem actors play key roles, and instead focus on the only actors involved with decision making stage. They do contend that it was only a one-day workshop, so they were not able to determine the long term change in participant beliefs.

Methods of assessing outcomes of participatory modeling

In this section, I present a review of the methods of assessing PM outcomes, starting with projects that did not use any formal method, and progressing through projects where the method of assessment was not a comparison of before and after, or was very qualitative. Finally, I present the few studies that used quantitative means to measure PM outcomes.

Outcomes from PM should be analyzed (Bots et al. 2008, Korfmacher 2001, Pahl-Wostl 2002, Van den Belt 2004, Voinov and Gaddis 2008). Rouwette et al. (2002) presented a meta-analysis of group model building. They called for uniformity in assessment, stating that it will facilitate easier cross-case comparison, and standardize the PM practice. Other PM work also advocated this need for uniformity (Korfmacher, 2001). However, after a decade or more of researchers advocating greater uniformity, great variation still exists in the method of assessment. More recent frameworks for PM still identified a need for conformity in analyzing changes in participant beliefs following participatory modeling (Jones et al. 2008), and the method of assessment still varied widely among PM cases. There are several examples of the evaluation of participants engaged in a PM exercise being measured through informal discussion of results/outcomes, such as where there was a discussion about the recommendations by the participants (Gaddis et al. 2007), or where the outcomes were provided to local policy makers and directly influence dialogue, policy evaluation, and agenda setting

(Sandker et al. 2009). Sandker et al. (2009) discussed their specific model outputs and the usefulness of participatory modeling in data collection and promoting dialogue.

Qualitative interviews with stakeholders can be used before the PM process in order to incorporate findings into model development (Haapasaari et al. 2012). More frequently, interviews are used to assess PM outcomes (Amatya et al. 2010, Becu et al. 2008, Cabrera et al. 2008). There is a lack of research where participant beliefs are measured both before and after a PM exercise. There is also little research where participants assess the participatory modeling process or outcomes. In some cases, interviews were conducted before and after participatory modeling exercises (Videira et al. 2012), or participant were given pre/post qualitative questionnaires (Fokkinga et al. 2009). In only a few cases pre-post surveys were employed to determine changes in participant beliefs or perceptions quantitatively (see Langsdale et al. 2009, Mathews et al. 2011, Robles-Morua et al. 2014, Rouwette et al. 2011).

Becu et al. (2008) introduced participatory companion modeling to farmers in rural Thailand. Post-interview analysis was done to see why attendance had dropped, and to look at participant perceptions of the model and process qualitatively. This analysis showed that farmers that attended all sessions had a clear understanding of the model, but participants had a hard time understanding that scenarios were not reality. The lack of quantitative measurements of changes in participant beliefs leaves us without a clear understanding of the source of the participants' confusion. Cabrera et al. (2008) discussed participatory modeling of dairy farming. Their work built on previous climate modeling work. They developed a system that modeled dairy farming with climate variability through a successful participatory process as measured by post interviews. However, belief in climate change is complex, and without baseline knowledge of the participant beliefs, there was no way to know whether PM facilitated changes.

Langsdale et al. (2009) conducted a series of five PM workshops. They employed surveys for participants to evaluate changes in beliefs regarding the watershed, the model developed, and self-efficacy and comfort with it. However, the surveys were only employed after the final two workshops, and the participant attendance was inconsistent. The questions were not designed to be components of scalar variables.

Mathews et al. (2011) advocated evaluating the change in values, beliefs, and norms following PM. They used a quantitative survey to measure whether participant beliefs about climate change were different following the workshop to evaluate their process. They also measured prior knowledge and employment information. The questions were broad and were not designed to be stand-alone, but rather to work with a qualitative analysis which explored nuances of the individual responses. The questions were also direct and relied on self-reporting and self-analysis. As with Langsdale et al. (2009), questions were not designed to be components of scalar variables. Their findings indicate that after the workshops participants report that they learned new information. Some said their views changed regarding climate change, but without baseline numbers the change was impossible to quantify.

Robles-Morua et al. (2014) measured both change in participant beliefs and participant assessment of the PM process. They found that participant beliefs about water quality in the Sonora River Basin changed following a one-day PM workshop, and that participants said the workshop was worthwhile to attend. They were not able to measure if the change was long-term, however.

Research gap

Robles-Morua et al. (2014) began to fill the gap in PM literature of a lack of a focus by developing world PM on key actors in the policy process: the decision makers. However, their work was based on just a one day-long meeting that could not show long-term changes in participant beliefs. They also did not find any statistically-significant changes in participant beliefs about water quantity problems following the workshops, and they did not go far enough in assessing the change in participant self-efficacy and comfort level using models. My research measures the change quantitatively in these variables over a four-month period, which included three workshops where participants repeatedly were exposed to models and data.

Chapter 4: Research Design

This chapter presents my research design and methods. My primary research goals were to assess participant perceptions of the quality of the workshops and to assess workshop impacts on beliefs regarding hydrologic and water resource systems modeling. I created survey questions designed to measure their beliefs about their capacity to use and understand models, model usefulness and accuracy, regional water-related problems (causes, solutions, and impacts), their beliefs about climate change, and their assessment of the quality of the workshop process and outputs. For those variables expected to change as a result of the workshops, questions from the pre-survey were repeated in the post-survey. In this chapter I present my conceptual model, the workshop format, and my survey and data analysis methods.

Conceptual framework

This section describes the conceptual framework that I developed. The conceptual framework categorizes the variables that I identified and measured. For each category of variables, I will first discuss the variables that I measured and then the hypothesized relationships between them. This model is based on previous research in the overall project my work was a part of (see Robles-Morua et al. 2014, Brenna 2012).

The ultimate goal of this project was to fill the research gaps regarding PM in the developing world as it relates to the policy cycle, and measuring long-term PM outcomes quantitatively. The conceptual framework was designed to address each of these gaps, by measuring dependent, intervening, and confounding variables:

intervening variables to represent the workshop process and the models produced; possible confounding variables identified through a review of the demographics and experience of participants in the pilot workshop presented by Robles-Morua et al. (2014) (I hypothesized that the variables "Participant's prior experience with hydrologic and water resource systems model," and education, institution type, age, and gender, which have been grouped together into "Demographics", could possibly confound my results for the dependent variables); and dependent variables that were designed to fill the identified research gaps and were based on the research prior to my work (outlined below).

From Brenna (2012) I identified specific questions with regard to model use, comfort with models, trust in models, and climate change. These were grouped into the variables "Beliefs about personal capacity to use and understand water models," "Beliefs about usefulness of water models," "Beliefs about accuracy of water models" and "Beliefs about climate change." These variables were expected to change based on intervening variables "Exposure to water modeling tools" and "Exposure to the participatory modeling process." I hypothesized that participants who were exposed to water modeling through a participatory process would believe that water models are more useful and more accurate afterwards. Participants would have a higher belief in their personal capacity to use and understand models, and would likely agree more strongly that climate change will affect Sonora more in the future.

Robles-Morua et al. (2014) found no statistical change in participant beliefs about water quantity issues. They hypothesized that unlike with water quality problems, participants had already been exposed to information about water quantity problems and that the workshop did not introduce any new information to change their beliefs. In order to test this hypothesis, I grouped questions regarding water quantity issues into two variables: "Beliefs about water quantity problems, causes, and solutions," and "Beliefs about water quantity problem impacts." I hypothesized that these variables would likely both be positively influenced by "Exposure to water modeling tools" and "Exposure to the participatory modeling process" i.e. the intervening variables would increase the awareness of water quantity problems, causes, and solutions, and also impacts, and make beliefs stronger.

Finally, in order to evaluate the participatory process we employed, I created two additional dependent variables: "Evaluation of the water models produced during the workshop" and "Evaluation of the workshop process." These variables were designed to give insight into participant experiences at the workshop, and their satisfaction with the end result. I hypothesized that "Evaluation of the water models produced during the workshop" would be influenced by both intervening variables, but that "Evaluation of the workshop process" would change primarily because of "Exposure to the participatory modeling process."

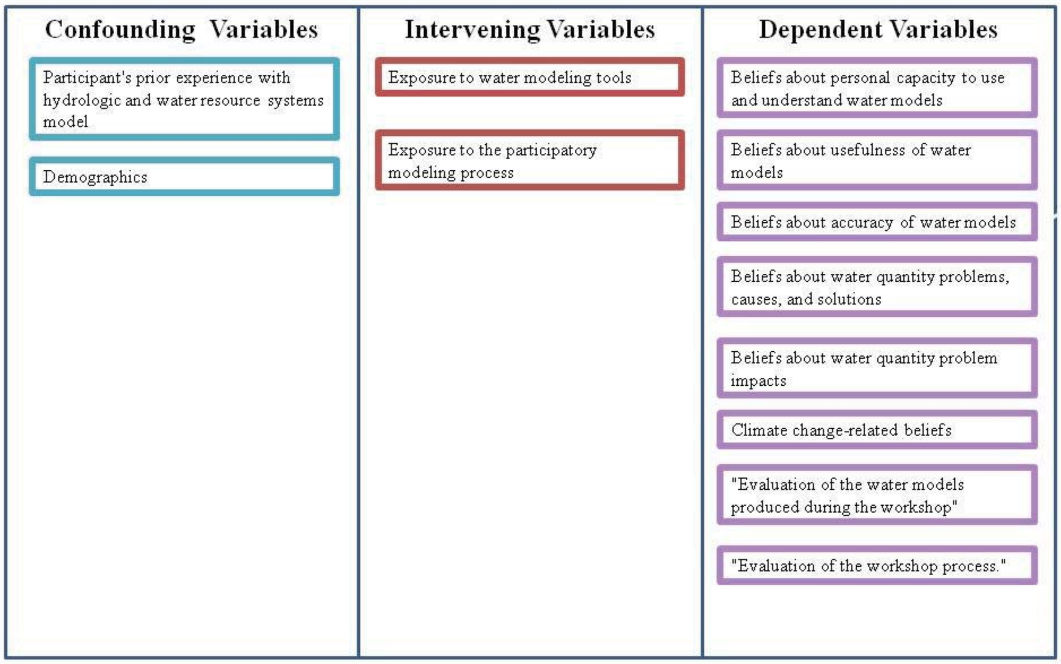

Figure 1. Conceptual framework diagram with variables: blue indicates pre-survey only; red indicates post-survey only; purple indicates variable is assessed on both surveys; dependent, intervening, and confounding variables are indicated at the top of each column

Workshop format and participatory process

In this section I present how participants were selected and contacted to attend the workshops, and the workshop design and schedule including the participatory process i.e. the methods employed to involve participants in the workshops and model development. Various government agency staff members, students, professors, and nongovernmental (NGO) staff were invited to attend the workshops through delivered, mailed, and emailed letters. Invitees were chosen because they worked on or studied water-related issues that could be elucidated through various types of models. They came from local, state, and federal agencies as well as universities and NGOs. These groups represented water managers in Sonora. An initial list was created of all the individuals involved in water (quantity or quality) or environmental management in Sonora. From this list, 5-7 individuals from large government agencies, 3-4 individuals from small agencies, and 1-2 university faculty and 1 graduate student from each academic institution were invited to attend. Individuals from NGOs, watershed council members and individuals from consulting agencies that work in Sonora were also invited.

One month prior to the workshops, a letter was delivered in person to the various agency directors. The letter requested that they allow their employees to attend the workshops. At this time, we also distributed individual invitations for the director to distribute to their respective employees. We sent email invitations two weeks prior to the first workshop, and in a number of cases we telephoned invitees to ensure attendance at the first workshop. Of the more than one-hundred and fifty invitees, eighty confirmed they would attend. Another twenty-four said they would like to come if they could, but were not sure if they could do so. Fifty-four invitees came to the first workshop and fifty-three took the pre-survey.

Table 1 shows a breakdown of the demographics of the participants that attended the first workshop. Of note is the level of participant education. All participants had at least a bachelor's degree, and the majority had either a Masters or PhD degree.

Table 1. Participant demographics

Gender	Female	Male	
	32% (N = 17)	68% (N = 36)	
Highest Degree	BS	MS	PhD
	40% (N = 21)	36% (N = 19)	25% (N = 13)
Positions	Government Agency	Academia	Consultant or NGO
	40% (N = 21)	45% (N = 24)	11% (N = 6)

There were three workshops. For each workshop, participants used small notebook-sized laptop computers provided by the conveners. On the first day of the first workshop, each participant shared a computer with one or two other attendees. Attendees were divided into two groups for the remaining three days of workshops and numbers were low enough that all participants had their own computer. Groups A and B were created randomly by alternately assigning groups as participants returned from lunch. The workshops for Group B were designed to be conducted at a more advanced level than for Group A in order to be able to determine which approach was more effective; however, the number of participants attending all three workshops was too low to compare between the two approaches.

The design of the workshops was based on experiences from the pilot project presented in Robles-Morua et al. (2014), and from other PM projects presented in the literature. The first workshop was a basic introduction to water modeling with discussion and brainstorming of ideas for the models to be presented at subsequent workshops. The workshop was two days long. The pre-survey was administered at the start of the first day. The first day included all participants. Workshop One took place in March of 2013, Two in April of 2013, and Three in June 2013.

Alex Mayer, principal investigator, Enrique Vivoni, co-principal investigator, and Kelsii Dana, an Arizona State University MS student in hydrology, gave most of the presentations, including the teaching and discussion sessions. Co-principal investigator Kathleen E. Halvorsen administered the pre-survey and was instrumental in the design and planning of the workshops.

First, the schedule of the workshop was presented. Then, participants were given an overview of the Sonora River Basin hydrology, climate, and water use. They were introduced to water resource systems modeling and the HEC-HMS software. This was followed by a group discussion of Sonora River Basin water resource systems and the components that the hydrologic model should include. After lunch, there was an activity that gave participants the opportunity to use the modeling software STELLA to manipulate a hydrologic model with a baseline climate scenario. Finally, the participants discussed the necessary inputs and outputs for a hydrologic model of the Sonora River Basin watershed. The next day, participants were divided into groups A and B. Group A attended the morning session, and group B the afternoon session. Both sessions began with an introduction to the modeling and climate change approach followed by a hands-on laptop activity that allowed the participants to use a HEC-HMS model of a watershed similar to the Sonora River Basin. A short break was followed by another hands-on HEC-HMS activity. Finally, the water resource systems components and model inputs and outputs that would be included in the working water resource systems model for Workshop Two were reviewed with the participants. Participants were asked to discuss the components and features that they would like to see included in the models. There were three main groups of suggestions: predictions of future water use, future water supply augmentation, and performance measures for the SRB water resource system.

For predictions of future water use, participants wanted residential, industrial, and agricultural water use predictions included. They suggested individual components of these, such as rates of population increase which would lead to greater water use, for example. For future supply augmentation, participants wanted to see things such as reforestation and treating wastewater included. Performance measures suggested included the fraction of the demand volume met by supply, the number of hours per day that water is restricted for users, the fraction of water provided to different use categories (residential, commercial, agricultural, and industrial), and changes in ground water levels, among others. Of these suggestions, the revised model included components that represented the different water use categories (such as domestic water user, agricultural water use, etc.). For these categories, return flow coefficients were included that modeled what portion of water was put back into the system. For example, domestic water use could consume 10% of the available water, but 90% of that could be treated and put back into the system.

El Molinito was modeled, with inflows represented by the HEC HMS model outputs, and operating rules determining withdrawals to the aqueduct and how much water is released downstream. Aquifer models (using HEC HMS) included several inflows and outflows including pumping and return flow, and showed the change in groundwater level that resulted. Climate scenarios were used to test the model against known events, and to make future projections.

Workshops Two and Three were half-day workshops with the same two groups. Workshop Two participants were presented with the results of the hydrologic model that was created between the first and second workshops. They discussed the results, and were presented with the new infrastructure scenarios that would be used with the hydrologic model in workshop three. They were also presented with the new water resource systems model and discussed its features before using it in an activity. Finally, the scenarios for the Sonora River Basin presented earlier in the day were elaborated on, and the participants discussed the possibilities in small groups. For these scenarios, participants were asked to consider categories of future water resource uncertainties, such as demand, climate, and supply infrastructure. Ideas, such as developing a "water culture" that is more conscious of water use, and novel ways to increase water supply, such as desalinization were put forth. Many participants discussed population increases, and increased urbanization in the future as well.

Workshop Three was similar to Workshop Two. Attendees undertook an activity with the final version of the combined water resource systems-hydrologic model. Then, they discussed the development strategy for water resources in the Sonora River Basin, using the model. Finally, the participants further discussed the water resource development strategy, and following another activity where they played through scenarios using the model, the participants were asked to justify inputs and adjustments they made in their individual models.

Table 2 shows the attendance for each workshop. Attendance was initially 53 participants. Only 28 participants returned for Workshop Two, and an effort was made to contact all of the original participants to encourage their attendance at Workshop Three. Attendance at workshop 3 rose slightly to 30 participants.

Table 2. Workshop attendance

	Session		
	A	B	Total
Workshop One, Day One	25	28	53
Workshop Two, Day Two	21	20	41
Workshop Two	15	13	28
Workshop Three	16	14	30

Survey methods

This section presents the methods used in survey construction and administration. First, I present the structure of the survey and methods used to create it. Then, I discuss how the survey was administered. In the next section I present my methods for survey data analysis.

The surveys were constructed using the conceptual model described in the previous section and the related prior work described in Robles-Morua et al. 2014. For each variable identified in the model, the surveys included sets of questions designed to be grouped together to create a scale measuring that variable. Each question or item was designed to measure one facet or component of these complex variables.

The survey was developed in English and translated into Spanish for administration. My translations were proof read and edited by two native Spanish speakers familiar with the engineering and modeling terms used, and reviewed by investigators working on the overall project. The questions were designed to vary in direction of answers (for example, some workshop assessment questions might read as describing the workshops negatively, others positively) in order to minimize question bias toward the positive and to encourage respondents to read each question carefully. English and Spanish versions of the surveys are presented in Appendix One through Four.

The pre-survey was given at the start of Workshop One. Participants were assigned a survey number that was written on the pre and post-surveys and recorded along with their name so that we could compare pre and post-survey responses. The post survey was administered immediately following the final activity of the Third Workshop. In both cases, survey numbers were checked a second time when the participants returned the survey. Responses were stored in password protected sites separate from respondent names.

Data analysis

This section presents my methods of data analysis for the pre-post survey data collected. First, I will present the method of data entry and coding of the item responses in the survey. Then, I will discuss my methods for analysis.

Following Workshops One and Three, the survey data was entered immediately into an Excel spreadsheet to ensure no data was lost in transit from Hermosillo to Houghton. Data was triple checked for accuracy by two individuals, and any errors corrected. The Excel spreadsheet was converted into an SPSS data file. Each item from the survey was encoded as a variable in SPSS. For items that I previously made negative, I reversed the response values and created new variables so that those items could be included in the variable scales. Variables such as workshop attendance were also encoded into seven categories ranging from "attended all workshop sessions" to "attended only first session of first workshop." These seven categories were simplified into two main attendance categories for my analysis: "attended all workshop sessions" and "did not attend all workshop sessions."

Following the pre-survey, I selected items from each variable that correlated well with each other and used them to create scales. Cronbach's alpha values from each grouping were used to determine the internal consistency. Once I identified items with high Cronbach's alpha values (> 0.6), I found the mean value of all responses for all of the items. This value is the scale value.

For my analysis, I first looked for any high or low values in the mean responses for each item. Then, using an independent sample T-test, I compared the pre-survey item means for the group that attended all workshop sessions with those of the group that did not attend all workshop sessions. When I found a difference between these two groups, I used cross-tabulation to try and identify possible causes of this difference. After that, I analyzed the scale mean for each variable. Finally, for variables where I needed to compare pre-survey means with post survey means, I used a paired sample T-test to compare both individual items and scale means.

Chapter 5: Results

This chapter presents results from my analysis of the major variables in my conceptual model as measured by a scale and its constituent items. I begin by presenting results that compare individual items for the group of people who attended all of the workshop sessions with the group of people who did not attend every session. I present the differences in mean responses between the two groups within each section. I have summarized all statistically significant differences in mean responses in Table 3. Next, for the group who attended all of the workshop sessions, I compare mean responses to each item between the pre and post- surveys. Finally, I present the results for all the scales together, including changes in the scale means between the pre and post-surveys. The scales all met a minimum Cronbach's alpha standard of 0.50.

The scale measuring "Participant's prior experience with hydrologic and water resource systems models" was designed to measure experience before the workshop so this scale was not included in the post-survey and no pre-post analysis was done. Similarly, the scales measuring participant assessments of the workshops were not included in the pre-survey since they would have nothing to assess.

Table 3. Item mean response differences between the group of participants who attended all sessions and the group who did not

		Participants that attended all workshop sessions: means and standard deviations		**Participants that did not attend all workshop sessions: means and standard deviations**			**Difference in mean responses between two groups of attendees**
Items	N	Mean	Std. Deviation	N	Mean	Std. Deviation	
I work with hydrologic models or water resource systems models weekly.	18	1.59	1.00	35	2.19	1.55	0.61*
Hydrologic models are useful tools.	18	4.41	1.33	35	4.86	0.35	0.45*
Domestic wastewater causes the lack of availability of water in the Sonora River Basin.	18	3.82	1.01	35	3.00	1.24	0.82*
The lack of water hurts the agricultural industry in our region.	18	4.53	0.87	35	4.00	1.10	0.53*
The climate is not changing.	18	1.06	0.24	35	1.76	0.92	0.71**
Climate change will not affect the Sonora River Basin in the future.	18	1.17	0.33	35	1.61	0.83	0.44**

* = Significant at 90% confidence level;
** = Significant at 95% confidence level;

Participant's prior experience with hydrologic and water resource systems models

This section describes the results from measurement of the variable "Participant's prior experience with water models." Table 4 shows results from the participants who attended all workshops. The scale mean was 2.94. This scale was only included in the pre-survey, because the prior experience of participants did not change over the course of the workshops. In this section, I first present the results from each survey question or item that went into the scale measuring this variable. I begin by comparing means for individual items between people who attended all of the workshops and people who did not attend every session. I also present the means for the items included in the scale and for the overall scale.

As shown in Table 3, for the people that attended all workshop sessions and those who did not, there was only one mean that was significantly different at the 90% confidence level. The people who attended all of the workshop sessions were significantly less likely to use water models weekly than the people who did not attend all of the workshops.

Table 4. Participant prior experience with hydrologic and water resource systems models (Cronbach's Alpha = 0.88)

Items	Participants that attended all workshop sessions: means and standard deviations		
	N	Mean	Std. Deviation
Participant's Prior Experience with Models	18	2.94	1.07
I have created hydrologic models or water resource systems models before.	18	2.78	1.63
I have encountered information derived from hydrologic or water resource systems models.	18	3.28	1.60
I have not encountered models of any type (meteorological models, climate models, etc.).	18	2.89	1.68
I have observed the use of hydrologic models or water resource systems models before.	18	3.83	1.62
I have not used hydrologic models or water resource systems models before	18	2.39	1.54
I work with hydrologic models or water resource systems models yearly.	18	2.44	1.46
I work with hydrologic models or water resource systems models weekly.	18	1.56	0.98

* = Significant at 90% confidence level;

Table 5. Institutional affiliations of participants (N = 53)

Institution	Number of participants	Percentage of total participants	Percentage of total participants that attended all sessions
Consultant	3	6%	0%
Federal Agency	7	14%	11%
State Agency	10	20%	117%
Mun. Agency	2	4%	0%
Academic	23	45%	67%
NGO	3	6%	6%
Other	3	6%	6%

Table 5 shows the institutional affiliations for those who attended all workshop sessions versus those who did not. Participants who attended all sessions were more likely to be in academia than those who did not attend all sessions. Table 6 is a cross-tab comparing the responses chosen to the question about using water models weekly for those who attended all workshop sessions versus those who did not. 18.9% of the participants reported using water models on a weekly basis. Only 1 of those participants attended all workshop sessions. Of the twelve participants from universities who attended all workshop sessions, eleven told us that they did not work with models weekly (See Table 7).

Table 6. Crosstab of weekly model use vs. attendance

Participant attendance	Yes, I use model weekly. (Response > 3)	No, I do not use water models weekly or not sure. (Response ≤ 3)
Attended all sessions	1	17
Did not attend all sessions	9	26

Table 7. Crosstab of weekly model use for participants that attended all session vs. affiliation with academia

Institutional affiliation	N	Yes, I used model weekly. (Response > 3)	No, I do not use water models weekly or not sure. (Response ≤ 3)
Academia	18	1	11
Not Academia	18	0	6

Beliefs about personal capacity to use and understand water models

This section describes results for the variable "Beliefs about personal capacity to use and understand water models." First, I present the results from the individual survey items. I begin by comparing means for individual items for people who attended all of the workshop sessions and people who did not. Next, I compare mean responses to each item between the pre and post- surveys for people who attended all workshops. Finally, I present the results for the scales that I constructed using the survey items. For these, I present the mean response for each scale. Then, I present any changes in the scale means between the pre and post survey.

First, I compared the mean pre-survey responses between the group of people that attended all workshop sessions and the group that did not. For the items that make up this scale, there are no significant differences.

In the pre-survey, participants believed that they were able to use water resources systems models before the workshops, and hydrologic models, yet they were unfamiliar with STELLA and HEC HMS. As Table 8 shows, participant responses to these questions changed significantly at the 95% confidence level. After the workshops, participants are significantly more likely to understand the difference between hydrologic and water resource systems models. After the workshops, participants are significantly less likely to agree with the survey statements that "I don't understand the basis of water resource systems models," and "I don't understand the basis of the model known as ‘HEC HMS.’" They are significantly more likely to agree with statements that "I understand how water resource systems models function," "I understand the basis of hydrologic models," and "I understand the basis of the software known as 'STELLA.’" The scale mean increased from 3.08 to 3.83 an increase statistically significant at the 99% confidence level indicating that participants are significantly more likely to believe that they can use and understand models after the workshops.

Table 8. Beliefs about personal capacity to use and understand water models – scale and items (Pre/Post-survey Cronbach's alphas = 0.89/0.93)

Items	Data from participants who attended ALL the workshops								
	Pre-Survey			Post-Survey			Pre-Post Survey Difference	T-test	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Change in Mean	T	Sig. (2-tailed)
Scale - Beliefs about personal capacity to use and understand water models	18	3.08	0.94	18	3.83	0.89	0.75***	-3.18	0.01
I understand the difference between water resource systems models and hydrologic models.	18	3.28	1.45	18	4.11	1.37	0.83**	-2.35	0.03
I don't understand the basis of water resource systems models.	18	2.50	1.15	18	1.94	1.06	-0.56*	1.82	0.09
I understand the basis of hydrologic models.	18	3.22	1.40	18	4.00	1.03	0.78**	-2.18	0.04
I don't understand the basis of the model known as "HEC HMS."	18	3.44	1.65	18	2.44	1.29	-1.00*	2.06	0.05
I understand the basis of the software known as "STELLA."	18	1.72	1.45	18	3.67	1.37	1.94***	-5.07	0.00
I understand how water resource systems models function.	18	3.06	1.30	18	2.11	1.23	-0.94**	2.79	0.01
I understand how hydrologic models function.	18	3.56	1.38	18	4.17	1.04	0.61	-1.54	0.14
I feel capable of working with water resource systems models.	18	3.94	1.16	18	4.11	0.96	0.17	-0.50	0.63
I feel capable of working with hydrologic models.	18	3.78	1.26	18	4.11	0.96	0.33	-1.03	0.32
I feel capable of working with the model known as "HEC HMS"	18	3.28	1.64	18	3.94	1.21	0.67	-1.44	0.17
I know a lot about water resource systems models.	18	2.11	1.02	18	2.50	1.15	0.39	-1.44	0.17

* = Significant at 90% confidence level;
** = Significant at 95% confidence level;
*** = Significant at 99% confidence level. Beliefs about usefulness of water models

Beliefs about the usefulness of water models

This section presents results from my analysis of the variable "Beliefs about usefulness of water models," and its constituent parts. First, I present the results from the survey items. I begin by presenting results that compare individual items for the group of people who attended all of the workshop sessions with the group of people who did not attend every session. I present the differences in mean responses between the two groups. Next, for the group who attended all of the workshop sessions, I compare mean responses to each item between the pre and post surveys. Finally, I present the results for the scales that I constructed using the survey items. For these, I present the mean response for each scale. Then, I present any changes in the scale means between the pre and post survey.

First, I compared the mean pre-survey responses between the group of people that attended all workshop sessions and the group that did not (Table 3). There is only one significant difference. For the item "Hydrologic models are useful tools," the mean response of participants who attended all of the workshop sessions was 4.44. For the other group, the response was 4.85. The difference is significant at the 90% confidence level. This indicates that the group that attended all of the workshop sessions believed less strongly that hydrologic models were useful than the other group.

As shown in Table 9, there were changes in the responses between the pre-survey and post-survey. For items "The water resource systems model known as 'HEC HMS' is a useful tool," "We should have more water resource systems models in my river basin," and "We should use more water resource systems models in my river basin," the changes were significant at the 99% confidence level, and show an increase in beliefs about the usefulness of water resource systems models. Changes for items

"We should have more hydrologic models in my river basin," and "We should have more hydrologic models in my river basin," indicate a similar increase in beliefs about the usefulness of hydrologic models.

The scale mean increased from 4.04 to 4.85, a significant change at the 99% confidence level. While participants believed models to be useful before the workshops, they are significantly more likely to believe this now.

Table 9. Beliefs about usefulness of water models – scale and items (Pre/Post-survey Cronbach's alphas = 0.89/0.79)

Items	Data from participants who attended ALL the workshops								
	Pre-Survey			Post-Survey			Pre-Post Survey Difference	T-test	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Change in Mean	T	Sig. (2-tailed)
Scale - Beliefs about usefulness of water models	18	4.04	0.97	18	4.85	0.25	0.81***	-3.45	0.00
Hydrologic models are useful tools.	18	4.44	1.29	18	4.83	0.38	0.39	-1.16	0.26
The water resource systems model known as "HEC HMS" is a useful tool.	18	3.33	1.41	18	4.83	0.38	1.50***	-4.47	0.00
We should have more water resource systems models in my river basin.	18	4.11	1.13	18	4.89	0.32	0.78***	-2.96	0.01
We should use more water resource systems models in my river basin.	18	4.00	1.14	18	4.83	0.38	0.83***	-3.22	0.01
We should have more hydrologic models in my river basin.	18	4.17	1.10	18	4.89	0.32	0.72**	-2.72	0.01
We should use more hydrologic models in my river basin.	18	4.17	1.10	18	4.83	0.38	0.67**	-2.61	0.02

** = Significant at 95% confidence level;
*** = Significant at 99% confidence level.

Beliefs about the accuracy of water models

This section presents results from my analysis of the scale "Beliefs about accuracy of water models," and its constituent items. First, I present the results from the survey items. I begin by presenting results that compare individual items for the group of people who attended all of the workshop sessions with the group of people who did not attend every session. I present the differences in mean responses between the two groups. Next, for the group who attended all of the workshop sessions, I compare mean responses to each item between the pre and post surveys. Finally, I present the results for the scales that I constructed using the survey items. For these, I present the mean response for each scale. Then, I present any changes in the scale means between the pre and post-survey.

First, I compared the mean pre-survey responses between the group of people that attended all workshop sessions and the group that did not. There were no significant differences in item responses. Table 10 shows that pre-survey responses to the items "Water resource systems models can predict the impacts of climate change," and "Hydrologic models can predict the impacts of climate change," (4.06 and 4.33 respectively) indicate that individuals believed in the accuracy of water models in predicting climate change impacts. From the pre-survey to the post-survey, there were no significant changes in item responses.

Participants neither agree nor disagree that water models are exact. From the pre-survey to the post-survey, no significant changes were observed in this scale. This indicates that statistically, participants did not believe models were more or less "exact" after they participated in the workshops.

Table 10. Beliefs about accuracy of water models – scale and items (Pre/Post-survey Cronbach's alphas = 0.83/0.76)

Items	Data from participants who attended ALL the workshops								
	Pre-Survey			Post-Survey			Pre-Post Survey Difference	T-test	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Change in Mean	T	Sig. (2-tailed)
Scale - Beliefs about accuracy of water models	17	3.21	0.78	17	3.00	0.86	-0.21	0.92	0.37
The software known as "STELLA" is not a useful tool.	18	2.28	1.18	18	1.78	1.17	-0.50	1.53	0.14
Water resource systems models are accurate tools.	18	2.44	0.86	18	2.44	1.29	0.00	0.00	1.00
Hydrologic models are accurate tools.	18	2.78	1.11	18	2.44	1.25	-0.33	1.06	0.30
The water resource systems model known as "HEC HMS" is an accurate tool.	17	2.71	1.05	17	2.47	1.28	-0.24	0.67	0.51
Water resource systems models can predict the impacts of climate change.	18	4.06	1.16	18	3.72	1.13	-0.33	1.14	0.27
Hydrologic models can predict the impacts of climate change.	18	4.33	0.84	18	4.00	0.91	-0.33	1.37	0.19

Beliefs about water quantity problems and causes

This section presents results from my analysis of the scale "Beliefs about water quantity problems, causes, and solutions," and its constituent items. First, I present the results from the survey items. I begin by presenting results that compare individual items for the group of people who attended all of the workshop sessions with the group of people who did not attend every session. I present the differences in mean responses between the two groups. Next, for the group who attended all of the workshop sessions, I compare mean responses to each item between the pre and post surveys. Finally, I present the results for the scales that I constructed using the survey items. For these, I present the mean response for each scale. Then, I present any changes in the scale means between the pre and post survey.

First, I compared the mean pre-survey responses between the group of people that attended all workshop sessions and the group that did not. Table 3 shows results from my analysis. Those that attended all workshop sessions had a mean response of 3.83 for the item "Domestic wastewater causes the lack of availability of water in the Sonora River Basin," indicating that they believed that domestic wastewater was a cause for water quantity problems. Individuals that did not attend all workshop sessions had a mean response of 3.00, indicating a significantly lower belief in domestic wastewater being a cause of water quantity problems. In Table 11, participants agreed that "Water demand exceeds the available supply in the Sonora River-basin," with a mean response of 4.00. There were no significant changes in mean response for items that comprise this scale between the pre-survey and post-survey.

The pre-survey value mean scale of 3.75 indicates that participants did believe that there were water quantity problems. No significant changes were observed in this scale, or among the three constituent items indicating that the participants' beliefs did not change because of the workshops.

Table 11. Beliefs about water quantity problems and causes– scale and items (Pre/Post-survey Cronbach's alphas = 0.54/0.70)

Items	Data from participants who attended ALL the workshops								
	Pre-Survey			Post-Survey			Pre-Post Survey Difference	T-test	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Change in Mean	T	Sig. (2-tailed)
Scale - Beliefs about water quantity problems and causes	17	3.75	0.86	17	3.65	1.03	-0.10	0.41	0.68
The Sonora River Basin has sufficient water to satisfy the basic needs of everyone in the basin.	18	2.72	1.45	18	2.61	1.38	-0.11	0.37	0.72
Water demand exceeds the available supply in the Sonora River-basin.	17	4.00	1.12	17	3.82	1.29	-0.18	0.53	0.61
Domestic wastewater causes the lack of availability of water in the Sonora River Basin.	18	3.83	0.99	18	3.67	1.19	-0.17	0.53	0.60

Beliefs about water quantity problem impacts

This section presents results from my analysis of the scale "Beliefs about water quantity problem impacts," and its constituent items. First, I present the results from the survey items. I begin by presenting results that compare individual items for the group of people who attended all of the workshop sessions with the group of people who did not attend every session. I present the differences in mean responses between the two groups. Next, for the group who attended all of the workshop sessions, I compare mean responses to each item between the pre and post surveys. Finally, I present the results for the scales that I constructed using the survey items. For these, I present the mean response for each scale. Then, I present any changes in the scale means between the pre and post survey.

First, I compared the mean pre-survey responses between the group of people that attended all workshop sessions and the group that did not. Table 3 shows that there was a significant difference at the 90% confidence level for responses to the item "The lack of water hurts the agricultural industry in our region." The group that attended all workshop sessions had a mean response of 4.56, indicating that they agree to strongly agree with the statement. The group that did not attend all workshop sessions had a mean response of 4.03, indicating that they did not agree as strongly. As shown in Table 12, for items "The lack of water hurts the manufacturing industry in our region," "The lack of water reduces population growth in our region," "The lack of water reduces economic development in our region," pre-survey responses indicated that the group agreed with all of these statements.

From the pre-survey to the post-survey, there was a significant, negative change (-0.89) at the 99% confidence level in the mean response for the item "The lack of water reduces population growth in our region." This indicates that participants agreed less with this statement after the workshops. Participants agreed less with the statement "The lack of water reduces economic development in our region," after the workshops, with a change in the mean response of -0.72, which is significant at the 95% confidence level.

The change in scale mean from the pre-survey (4.35) to the post-survey (3.83) was significant at the 90% confidence level. This negative change indicates a decrease in beliefs about the impact of water quantity problems in the region. The high pre-survey mean shows a general belief in impacts resulting from water quantity problems.

Table 12. Beliefs about water quantity problem impacts – scale and items (Pre/Post-survey Cronbach's alphas = 0.93/0.91)

Items	Data from participants who attended ALL the workshops								
	Pre-Survey			Post-Survey			Pre-Post Survey Difference	T-test	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Change in Mean	T	Sig. (2-tailed)
Scale - Beliefs about water quantity problem impacts	18	4.35	1.04	18	3.83	1.08	-0.51**	2.52	0.02
The lack of water hurts the agricultural industry in our region.	18	4.56	0.86	18	4.33	1.19	-0.22	0.78	0.45
The lack of water hurts the manufacturing industry in our region.	18	4.28	1.32	18	4.06	1.26	-0.22	1.07	0.30
The lack of water reduces population growth in our region.	18	4.17	1.25	18	3.28	1.23	-0.89***	3.50	0.00
The lack of water reduces economic development in our region.	18	4.39	1.09	18	3.67	1.19	-0.72**	2.85	0.01

** = Significant at 95% confidence level;
*** = Significant at 99% confidence level.

Climate change-related beliefs

This section presents results from my analysis of the scale "Climate change-related beliefs" and its constituent items. First, I present the results from the survey items. I begin by presenting results that compare individual items for the group of people who attended all of the workshop sessions with the group of people who did not attend every session. I present the differences in mean responses between the two groups. Next, for the group who attended all of the workshop sessions, I compare mean responses to each item between the pre and post surveys. Finally, I present the results for the scales that I constructed using the survey items. For these, I present the mean response for each scale. Then, I present any changes in the scale means between the pre and post survey.

First, I compared the mean pre-survey responses between the group of people that attended all workshop sessions and the group that did not. As shown in Table 3, there were two significant differences in the mean responses for items "The climate is not changing," and "Climate change will not affect the Sonora River Basin in the future." For the first item, the group that attended all workshop sessions had a mean response of 1.06, while the other group had a mean response of 1.72. This indicates that the group that attended all workshop sessions believed strongly in climate change, while the other group did not believe as strongly. For the item "Climate change will not affect the Sonora River Basin in the future," the group that attended all workshop sessions had a mean response of 1.17, indicating strong disagreement with that statement. The group that did not attend every workshop session had a mean response rate of 1.61. The differences are significant at the 95% confidence level.

In Table 13, the mean response for item "The cause of climate change is anthropogenic," changed from a pre-survey mean of 4.11, to 3.94, which is a significant change at the 90% confidence level. Participants believe less that the cause of climate change is anthropogenic following the workshops. No significant pre-post changes were observed in the scale mean.

Table 13. Climate change related beliefs – scale and items (Pre/Post-survey Cronbach's alphas = 0.77/0.51)

Items	Data from participants who attended ALL the workshops								
	Pre-Survey			Post-Survey			Pre-Post Survey Difference	T-test	
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	Change in Mean	T	Sig. (2-tailed)
Scale - Climate change- related beliefs	18	4.37	0.59	18	4.33	0.43	-0.05	0.46	0.65
The climate is not changing.	18	1.06	0.24	18	1.17	0.38	0.11	-1.46	0.16
I believe the Sonora River Basin is prepared for the impacts of climate change.	18	1.78	0.81	18	2.00	1.03	0.22	-1.46	0.16
Climate change will not affect the Sonora River Basin in the future.	18	1.17	0.38	18	1.17	0.38	0.00	0.00	1.00
Climate change has already affected the Sonora River Basin.	18	4.28	1.07	18	4.00	1.19	-0.28	0.75	0.46
The cause of climate change is anthropogenic.	18	4.11	0.90	18	3.94	1.00	-0.17*	1.84	0.08

** = Significant at 90% confidence level.

Evaluation of the water models produced during the workshop

Table 14 shows that participants generally agreed that their opinions were included in the final version of the water resource systems model produced with STELLA, and that they have confidence in it. They agreed that they learned a lot about hydrologic models. They also expressed confidence in the version of the HEC HMS model that was produced with their input. The mean for this scale was 4.26. Overall, participant responses indicate satisfaction with and confidence in the workshops results.

Table 14. Evaluation of the water models produced during the workshop – scale and items (Cronbach's alpha = 0.81)

Data from participants who attended ALL the workshops			
Items	**Post-Survey**		
	N	Mean	Std. Deviation
Scale-Evaluation of the water models produced during the workshop	17	4.26	0.70
I did not contribute to the final version of "STELLA" that was produced in these workshops.	18	2.06	1.47
My opinions were included in the final version of "STELLA" that was produced in these workshops.	18	4.17	1.15
I did not contribute to the final version of "HEC HMS" that was produced in these workshops.	18	2.22	1.44
I have confidence in the final version of "STELLA" that was produced in these workshops.	18	4.33	0.77
I do not have confidence in the final version of "HEC HMS" that was produced in these workshops.	18	1.78	1.00
In this workshop, I learned a lot about hydrologic models.	18	4.28	0.83

Evaluation of the workshop process

As shown in Table 15, participants who attended all the workshops reviewed them positively. They agreed most strongly with the statements "The pace of the workshops helped me to understand the basis of the models," and "The hands-on aspects that were used with the models on my computer were useful." The mean value of 4.31 for this scale indicates a favorable evaluation of the workshop process.

Table 15. Evaluation of the workshop process – scale and items (Cronbach's alpha = 0.43)

Data from participants who attended all the workshops			
Items	**Post-Survey**		
	N	Mean	Std. Deviation
Scale - Evaluation of the workshop process	18	4.31	0.49
In general, the activities were understandable.	18	4.33	0.97
I didn't understand the views of the other participants about water.	18	1.89	1.23
The pace of the workshops did not help me to understand how the models work.	18	1.94	1.21
The pace of the workshops helped me to understand the basis of the models.	18	4.61	0.50
The hands-on aspects that were used with the models on my computer were understandable.	18	4.11	1.08
The hands-on aspects that were used with the models on my computer were useful.	18	4.61	0.50

Chapter 6: Discussion

Addressing gaps in the research regarding participatory modeling in the developing world and quantitative assessment methods for changes in participant beliefs about models, climate change, water quantity problems, causes, and impacts, and the PM process and PM outputs goes hand -in-hand with meeting the water management challenges facing Sonora. Overall, changes in participant beliefs were encouraging and showed that participatory modeling was an effective way to introduce new management tools to an area facing water management challenges.

In this chapter I present a discussion of the results from my research. First, I present my research questions. Then, I briefly answer each question in terms of my findings, and state whether these findings are supported by the literature. After that, I discuss the prior knowledge of the participants regarding water modeling, and then I discuss the intervening variables in terms of my hypothesized relationships with the dependent variables. Then, I discuss my findings in the context of the literature, and talk about the gap in the research this work filled. I also discuss whether the group that attended all workshop sessions was representative of the larger group of participants.

Research questions

The main research questions for this project were:

1. How will participatory water resource modeling impact participant comfort and self-efficacy with models?

2. Will participants have different beliefs regarding climate change, and regional water-quantity problems (causes, solutions, and impacts) after participating in discussion and PM activities?

In terms of the intervening variables included in the conceptual framework, these questions asked how "Exposure to water modeling tools" and "Exposure to the participatory modeling process" would influence participant comfort and ability to use and understand water models, and their beliefs about climate change, and regional water-quantity problems (causes, solutions, and impacts).

The answer to the first question is that participants showed an increase in efficacy and comfort with models after the workshops. Results from the scale analysis of the variable "Beliefs about personal capacity to use and understand water models" indicated that participants were significantly more likely to believe that they could use and understand water models after participating in the workshops. This was consistent with other work assessing comfort and efficacy with computer models (Cockerill et al. 2004, Van den Belt 2004, Voinov and Gaddis 2008, Robles-Morua et al. 2014). Participants were also significantly more likely to believe that water models were useful after the workshop. Results from comparison of pre and post averages for the scale measuring the variable "Beliefs about usefulness of water models" indicated that participants were significantly more likely to believe water models were useful after the workshops than before the workshops. This was also consistent with prior research (Bots et al. 2008, Cockerill et al. 2004, Dietz et al. 2004) and with the pilot project findings (Robles-Morua et al. 2014).

However, there was no statistically significant change in the variable "Beliefs about accuracy of water models" before and after the workshops. Participants were neutral on model accuracy before the workshop and still were neutral afterward. This result was interesting when compared with the participant belief about the usefulness of models. Participants believed that models were useful but they were neutral about their accuracy. Although they did not measure perceptions of model accuracy, Robles-Morua et al. (2014) found that participants trusted models and the results obtained from them. In my work, the word used as a Spanish equivalent of "accurate" was "exacta." This word is sometimes used to mean "precise." It is possible participants did believe more strongly that models were accurate after the workshops, but not more precise. It is also possible that participants believed models were useful as a teaching tool. Participants did show a significant increase in efficacy and comfort with water models after the workshops, and they did believe that they learned a lot about water models.

The answer to the second research question is that there was no statistically significant change in the variable "Beliefs about water quantity problems and causes." On average, participants tended to agree that there are water quality problems in the SRB. They agreed that "Water demand exceeds the available supply in the Sonora River-basin," and that "Domestic wastewater causes the lack of availability of water in the Sonora River Basin." There was a statistically significant negative change in the variable "Beliefs about the water quantity problem impacts" indicating that participants believed less strongly that water quantity problems currently impact the local region. This differs from the findings of Robles-Morua et al. (2014). They found no significant change in beliefs about water quantity related impacts. The mean response for the item

"The lack of water reduces population growth in our region," was significantly lower on the post survey indicating participants were less likely to believe that water quantity problems currently reduce regional population growth. The mean response to the item "The lack of water reduces economic development in our region," was also significantly lower on the post-survey. This change may have been due to data presented during the workshops and in the scenarios that indicated that the population was projected to continue growing, and in some of our workshop simulations the population growth rate was set to increase despite growing water scarcity. There may have been a certain amount of confusion about the predictive nature of scenarios, which was consistent with the findings of Becu et al. (2008). On some level, participant beliefs about future projections of the models may have been influenced by the hypothetical scenarios we introduced during the workshops. These scenarios were designed as tools for testing model functionality and for teaching participants to use models in real-world situations. However, the scenarios were in some cases designed to represent extreme situations, such as unchecked population or large economic growth. Participants may have been influenced by this. Responses to the individual post-survey items indicate that participants' believed less strongly after the workshops that water quantity problems impacted population growth and economic development in the SRB.

After the workshops, participants were significantly less likely to agree with the statement "The cause of climate change is anthropogenic," indicating a lower overall belief that climate change is indeed caused by human actions. This was another surprising finding. A possible cause for the change could be data on natural climate variability presented during the workshops to which participants had not previously been exposed. Researchers showed the natural cycles that have occurred in Sonora in the past. Some participants may have interpreted this as evidence of non-anthropogenic causes of climate change (i.e. a natural cycle). A modification of the PM process may be necessary, given these findings, in order to avoid biasing participant beliefs.

Prior experience with models, evaluation of the water models produced during the workshop, and evaluation of the workshop process.

Overall, participants did not have much prior experience with water models. Most had observed the use of water models, and some had encountered information derived from them. These results were consistent with the findings of Robles-Morua et al. (2014). Most participants had not worked with water models on a weekly basis, and only some on a yearly basis. Likely, prior experience did have an effect on participant comfort and efficacy with water models, beliefs about the usefulness of water models, and beliefs about the accuracy of water models. There was a statistically significant difference between the group of participants that attended all of the workshop sessions and those that did not regarding whether they had used models on a weekly basis, yet there was not a statistically significant difference between those same two groups for comfort and efficacy with water models, as measured by the variable " Beliefs about personal capacity to use and understand water models". The group that did not attend every session was more likely to use models on a weekly basis. One would expect that group to feel more comfortable and able to use models, yet this was not the case. This is perhaps because the variable was designed to measure comfort and efficacy with models in general, but also comfort and efficacy with the specific modeling software we employed for the workshops. It is likely that the participants who used models weekly did not use these modeling software.

Participants had a positive opinion of the workshop outputs. The scale mean value for the variable "Evaluation of the water models produced during the workshop" indicated that the participants were satisfied with the final versions of the water models. On average, participants evaluated the workshop process positively as well. In relation to the intervening variables, satisfaction with the end products likely resulted from both exposure to models during the workshops, and the participatory process, They believed that the activities were understandable, and that the workshop speed was conducive to understanding the basis and function of the models. They also believed that the hands on aspects of the workshops were understandable and useful.. They felt that they contributed to the water models and that their opinions were included in them. This suggests that the changes made to the models based on participant contributions contributed to their satisfaction. They also felt that they learned a lot about hydrologic models, likely due to exposure to hydrologic models and the participatory process that involved the participants in model creation. Participants also indicated that they have confidence in the final versions of the water models produced. The importance of participant trust in the model produced during PM to the outcomes of the project is supported in the literature (Voinov and Gaddis 2008).

Previous water-related PM work in Latin America has largely been designed to equip water users to circumvent the failed policy institutions (e.g. Sandoval 2004) or give a voice to resource users (e.g. Luijten et al. 2003, Pierce et al. 2009). This study showed that PM in the developing world can be directed towards decision makers directly, and can equip them to make policy decisions. Increase comfort and efficacy with water models can lead to greater implementation of these types of tools to aid management decisions. Both questions research questions relate to decision makers. The ability to comfortably use models may enable decision makers to look at policy alternatives and make better decisions. Models could be used to show possible effects of water management strategies, and to better understand the dynamics of the water resource management systems in Sonora. Changing beliefs about climate change, water-quantity problems, causes, solutions and impacts may also affect agenda setting.

There is still great variation in the methods for assessing success in PM despite the numerous calls for uniformity (Jones et al. 2008, Korfmacher 2001, Rouwette et al. 2002). This work provided a basis for quantitatively measuring the long term changes in participant beliefs following PM.. My work presents a method for assessment that can be used for cross-case comparison. My research design originally planned for much higher attendance. The lower numbers did show that this method of analyzing long-term changes in participant beliefs is applicable to groups consisting of as few as eighteen people, which satisfies Videira et al.'s (2009) call for small group size. A larger group may not have been as conducive to open discussion and may have prevented some participants from having input in the model. This method allows for an assessment of the changes to participants with regard to efficacy and comfort levels with models, and allows researchers to determine what affect the PM process had on participants quantitatively. It also allows researchers to determine whether participant trust in the models produce, as advocated in the PM literature (Voinov and Gaddis 2008).

Conclusion

I discussed some of the results from my work in the previous section. In this section, I provide some conclusions about my work and the knowledge gained from it.

As I stated, both of my research questions relate to decision makers. Equipping decision makers with the ability to use water models, and increasing their comfort with those models gives the actors that are directly involved with decision making a tool to evaluate different alternatives and make better management decisions.

In the context of PM research, this is an important difference my work shows from other work in the developing world. Based on the results, decision makers are more comfortable with models and better able to use them. They also feel that models are more useful. Both of the changes were also long term (over the course of three months). This shows that PM is capable of aiding the decision making stage of the policy cycle in the developing world, where complex models are not as often employed as in the developed world.

Future work should expand the application of PM in the developing world to include more decision makers in more areas of natural resource management. Also, future water resource decision making in Sonora should be analyzed, to determine if the changed beliefs about models actually led to more water model use and changed the water policy process there.

As for the methods used to assess changes in participant beliefs, this method for assessing changes in participant beliefs can be applied in other PM work, and could lead to more uniform comparisons of variables in the PM process, such as group size.

The analysis of participant prior knowledge suggest that ideal group size for this assessment method should seek to balance the ability to closely involve all participants in model development which is provided by a smaller group, with the ability to measure changes in participant beliefs and derive statistically significant results, which is provided by a larger group. For example, participant's who worked with models on a weekly basis were not more or less able to use or understand models.

A larger participant group would have allowed for regression analysis to determine if there was a correlation between this and participant prior knowledge. However, a larger may have had detrimental effects on positive aspects of the workshop process, such as model discussion and scenario building. Future work in the PM field should explore participant group size and its effects on the PM process.

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Appendix: Survey questions

Below are the pre and post survey questions. For each question, participants were presented with a Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = agree strongly). They were asked to circle the number that corresponded to their level of agreement with the statement. All survey questions were written and presented in Spanish. They have been translated below for convenience. Each set of translated survey questions are followed by the original Spanish questions.

At the top of the first page of each survey, participants were shown the confidentiality statement below:

Confidentiality Statement (English)
The information obtained in this survey is strictly confidential. Responses will not be associated with any names.

Confidentiality Statement (Spanish)
La información obtenida en esta encuesta es estrictamente confidencial; no se asociará ninguno nombre con sus respuestas.

Pre-survey questions (English)

Part A: Prior experience with models

1. I have created hydrologic models or water resource systems models before.
2. I have encountered information derived from hydrologic or water resource systems models.
3. I have not encountered models of any type (meteorological models, climate models, etc.).
4. I have observed the use of hydrologic models or water resource systems models before.
5. I have not used hydrologic models or water resource systems models before
6. I work with hydrologic models or water resource systems models yearly.

7. I work with hydrologic models or water resource systems models weekly.

Part B: Beliefs about capacity to use and understand models

1. I understand the difference between water resource systems models and hydrologic models.
2. I don't understand the basis of water resource systems models.
3. I understand the basis of hydrologic models.
4. I don't understand the basis of the model known as "HEC HMS."
5. I understand the basis of the software known as "STELLA."
6. I understand how water resource systems models function.
7. I understand how hydrologic models function.
8. I don't understand how the model known as "HEC HMS" functions.
9. I understand how the software known as "STELLA" functions.
10. I feel capable of working with water resource systems models.
11. I feel capable of working with hydrologic models.
12. I feel capable of working with the model known as "HEC HMS."
13. I do not feel capable of working with the software known as "STELLA".
14. I know a lot about water resource systems models.
15. I do not know much about hydrologic models.
16. I do not know much about the model know as "HEC HMS."
17. I know a lot about the software known as "STELLA."

Part C: Beliefs about models

1. Water resource systems models are useful tools.
2. Hydrologic models are useful tools.
3. The water resource systems model known as "HEC HMS" is a useful tool.
4. The software known as "STELLA" is not a useful tool.
5. Water resource systems models are accurate tools.
6. Hydrologic models are accurate tools.
7. The water resource systems model known as "HEC HMS" is an accurate tool.
8. The software known as "STELLA" is not an accurate tool.
9. We should have more water resource systems models in my river basin.
10. We should use more water resource systems models in my river basin.
11. We should have more hydrologic models in my river basin.
12. We should use more hydrologic models in my river basin.
13. The water resource systems models actually used in the Sonora River Basin are not useful.
14. The hydrologic models actually used in the Sonora River Basin are not useful.
15. Water resource systems models can predict the impacts of climate change.
16. Hydrologic models can predict the impacts of climate change.
17. I do not want to have more training in the use of water resource systems models.
18. I do not want to have more training in the use of hydrologic models.

Part D: Beliefs about water quantity problems, causes, and solutions

1. The Sonora River Basin has sufficient water to satisfy the basic needs of everyone in the basin.
2. More hydrologic studies that help us understand the operation of the basin will help to resolve the problem.
3. Water demand exceeds the available supply in the Sonora River-basin.
4. The water demand DOES NOT exceed the qauntity of water that is available in the Sonora River basin at this moment, but it will in the future.
5. The lack of rain causes the lack of water in the Sonora River basin.
6. Agricultural waste water use causes the lack of available water in the Sonora River basin.
7. Domestic wastewater causes the lack of availability of water in the Sonora River Basin.
8. Better infrastructure WILL NOT help to resolve the problem of lack of water in the Sonora River basin.
9. We DO NOT have adequate infrastructure to distribute the available water in the Sonora River basin.
10. We DO NOT have adequate infrastructure to gather/collect the available water in the Sonora River basin.
11. More efficient use of water could help us to resolve the water quantity problem in the Sonora River basin.

Part E: Impacts from water quantity problems

1. There is excessive exploitation of underground water in the Sonora River basin.
2. The lack of water causes ecological problems.
3. The lack of water hurts the agricultural industry in our region.
4. The lack of water hurts the manufacturing industry in our region.
5. The lack of water reduces population growth in our region.
6. The lack of water reduces economic growth in our region.
7. There is NOT an excessive exploitation of water in the Sonora River basin.

Part F: Social impacts from water decisions

1. When there are conflicts, the water should be assigned to whoever will create the maximum benefit for all.
2. When there are conflicts, the water should be assigned to whoever has the greatest need.
3. When we have conflicts between domestic use of water and the use of water for agricultural use, the priority should be given to the domestic uses.
4. When we have conflicts between industrial use of water and the use of water for agricultural use, the priority should be given to the industrial uses.

5. When we have conflicts between industrial use of water and the use of water for domestic use, the priority should be given to the industrial uses.
6. In general, sometimes it is necessary to assign more water to some and less to others.
7. A decision to assign water needs to be fair for everyone.
8. In our region, the decisions to assign water are fair.

Part G: Climate change related beliefs

1. The climate is NOT changing.
2. I am familiar with the term climate change.
3. I believe that the Sonora River basin is prepared for the impacts from climate change.
4. Climate change will NOT affect Sonora in the future.
5. Climate change has already affected the Sonora River basin.
6. In the future, more serious floods will occur in the Sonora River basin due to climate change
7. The cause of climate change is anthropogenic (the result of human activities).
8. The cause of climate change is natural.
9. The protection of the atmosphere is a high priority.
10. In the future, there will be more serious droughts in the Sonora River basin due to climate change.
11. Climate change is going to create enormous problems for us in Mexico.
12. In the Sonora River basin, the infrastructure is already efficient to meet the challenge of climate change.

Part H: Demographics

1. What is your gender?
2. What is the highest level of education that you have completed?
3. In which type of institution do you work?
4. What is your age in years?

Pre-survey questions (Spanish)

Parte A: Experiencia anterior con modelos.

1. He creado personalmente modelos hidrológicos o de sistemas de recursos del agua con anterioridad.
2. He encontrado personalmente información de modelos hidrológicos o de sistemas de recursos del agua.
3. No he encontrado personalmente modelos de algún tipo (modelos meteorológicos, climáticos, etc.).
4. He observado personalmente el uso de modelos hidrológicos o de sistemas de recursos del agua con anterioridad.
5. No he utilizado modelos hidrológicos o de sistemas de recursos del agua personalmente en algún momento de mi trabajo.
6. Trabajo con modelos hidrológicos ni de sistemas de recursos del agua anualmente.
7. Trabajo con modelos hidrológicos o de sistemas de recursos del agua semanalmente.

Parte B: Creencias sobre capacidad para usar y comprender modelos.

1. Comprendo la diferencia entre modelos de sistemas de recursos del agua y modelos hidrológicos.
2. En general, no comprendo la base de los modelos de sistemas de recursos del agua.
3. En general, comprendo la base de los modelos hidrológicos.
4. No comprendo la base del modelo conocido como "HEC HMS".
5. Comprendo la base del software conocido como "STELLA".
6. En general, no comprendo cómo funcionan los modelos de sistemas de recursos del agua.
7. En general, comprendo cómo funcionan los modelos hidrológicos.
8. No comprendo cómo funciona del modelo conocido como "HEC HMS".
9. Comprendo cómo funciona el software conocido como "STELLA".
10. En general, me siento capaz de poder trabajar con modelos de sistemas de recursos del agua.
11. En general, me siento capaz de poder trabajar con modelos hidrológicos.
12. Me siento capaz de poder trabajar con el modelo conocido como "HEC HMS."
13. No me siento capaz de poder trabajar con el software conocido como "STELLA".
14. Sé mucho de los modelos de sistemas de recursos del agua.
15. No sé mucho de los modelos hidrológicos.
16. No sé mucho del modelo conocido como "HEC HMS."
17. Sé mucho del software conocido como "STELLA".

Parte C: Creencias sobre modelos.

1. En general, los modelos de sistemas de recursos del agua son herramientas útiles.
2. En general, los modelos hidrológicos son herramientas útiles.
3. El modelo de sistemas de recursos del agua conocido como "HEC HMS" es una herramienta útil.
4. El software conocido como "STELLA" no es una herramienta útil.
5. En general, modelos de sistemas de recursos del agua son herramientas exactas.
6. En general, modelos hidrológicos son herramientas exactas.
7. El modelo de sistemas de recursos del agua conocido como "HEC HMS" es una herramienta exacta.
8. El software conocido como "STELLA" no es una herramienta exacta.
9. Deberíamos tener más modelos de sistemas de recursos del agua en mi cuenca.
10. Debemos usar más modelos de sistemas de recursos del en mi cuenca.
11. Deberíamos tener más modelos hidrológicos en mi cuenca.
12. Debemos usar más modelos hidrológicos en mi cuenca.
13. Los modelos de sistemas de recursos del agua utilizados actualmente en la cuenca del Río Sonora no son útiles.
14. Los modelos hidrológicos utilizados actualmente en la cuenca del Río Sonora no son útiles.
15. Los modelos de sistemas de recursos del agua pueden predecir los impactos del cambio climático.
16. Los modelos hidrológicos pueden predecir los impactos del cambio climático.
17. No quiero tener más entrenamiento en el uso de modelos de sistemas de recursos del agua.
18. No quiero tener más entrenamiento en el uso de modelos hidrológicos.

Parte D: Creencias sobre los problemas de cantidad de agua: causas y soluciones.

1. La cuenca del Río Sonora tiene suficiente agua para satisfacer las necesidades básicas de todos en la cuenca.
2. Más estudios hidrológicos que nos ayuden a entender el funcionamiento de la cuenca ayudarán a resolver el problema.
3. La demanda de agua excede la cantidad de agua que se tiene disponible en la cuenca del Río Sonora.
4. La demanda de agua no excede la cantidad de agua que se tiene disponible en la cuenca del Río Sonora en este momento, pero lo hará en el futuro.
5. La falta de lluvia ocasiona la falta de agua disponible en la cuenca del Río Sonora.
6. El desperdicio de agua en el uso agrícola ocasiona la falta de disponibilidad de agua en la cuenca del Río Sonora.
7. El desperdicio de agua en el uso doméstico ocasiona la falta de disponibilidad de agua la cuenca del Río Sonora.

8. Mejor infraestructura no ayudará a resolver el problema de falta de agua en la cuenca del Río Sonora.
9. No tenemos la infraestructura adecuada para distribuir el agua disponible en la cuenca del Río Sonora.
10. No tenemos la infraestructura adecuada para recolectar el agua disponible en la cuenca del Río Sonora.
11. El uso más eficiente del agua nos ayudaría a resolver el problema de la cantidad de agua en la cuenca del Río Sonora.

Parte E: Los impactos de problemas de cantidad del agua.

1. Existe una explotación excesiva del agua subterránea en la cuenca del Río Sonora.
2. La falta de agua ocasiona problemas ecológicos.
3. La falta de agua perjudica a la industria agrícola en nuestra región.
4. La falta de agua perjudica a la industria manufacturera en nuestra región.
5. La falta de agua reduce el crecimiento de la población en nuestra región.
6. La falta de agua reduce el desarrollo económico en nuestra región.
7. No existe una explotación excesiva del agua de la cuenca del Río Sonora.

Parte F: Los impactos sociales de decisiones sobre agua.

1. Cuando hay conflictos, el agua debe ser asignada a quien la utilice para crear el mayor beneficio para todos.
2. Cuando hay conflictos, el agua debe ser asignada a quiénes tengan la mayor necesidad.
3. Cuando tenemos conflictos entre el uso doméstico del agua y el uso de agua para la agricultura, se debe dar prioridad al uso doméstico del agua.
4. Cuando tenemos conflictos entre el uso industrial del agua y el uso de agua para la agricultura, se debe dar prioridad al uso industrial del agua.
5. Cuando tenemos conflictos entre el uso industrial del agua y el uso doméstico, se debe dar prioridad al uso industrial del agua.
6. En general, a veces es necesario tomar la decisión que asignar más agua a unos y menos a otros.
7. Una decisión para asignar agua necesita ser justa para todos.
8. En nuestra región, las decisiones asignando agua son justas.

Parte G: Creencias relacionadas al cambio climático

1. El clima no está cambiando.
2. Estoy familiarizado con el término “cambio climático".
3. Creo que la cuenca del Río Sonora está preparada para los impactos del cambio climático.
4. El cambio climático no afectará a Sonora en el futuro.
5. El cambio climático ya afecta a la cuenca del Río Sonora.
6. En el futuro inundaciones más serias ocurrirán en la cuenca del Río Sonora debido al cambio climático.
7. La causa del cambio climático es antropogénica (resultado de actividades humanas).
8. La causa del cambio climático es natural.
9. La protección del medio ambiente es de alta prioridad.
10. En el futuro se producirán sequías más serias en la cuenca del Río Sonora debido al cambio climático.
11. El cambio climático va a crear problemas enormes para nosotros en México.
12. En la cuenca del Río Sonora, la infraestructura ya es suficiente para afrontar el reto del cambio climático.

Parte H: Demografía

1. ¿Cuál es su género?
2. ¿Cuál es el nivel más alto de educación que ha completado?
3. ¿En qué tipo de institución trabaja?
4. ¿Cuál es su edad en años?

Post-survey questions (English)

Part B: Beliefs about capacity to use and understand models

1. I understand the difference between water resource systems models and hydrologic models.
2. I don't understand the basis of water resource systems models.
3. I understand the basis of hydrologic models.
4. I don't understand the basis of the model known as "HEC HMS."
5. I understand the basis of the software known as "STELLA."
6. I understand how water resource systems models function.
7. I understand how hydrologic models function.
8. I don't understand how the model known as "HEC HMS" functions.
9. I understand how the software known as "STELLA" functions.
10. I feel capable of working with water resource systems models.
11. I feel capable of working with hydrologic models.
12. I feel capable of working with the model known as "HEC HMS."
13. I do not feel capable of working with the software known as "STELLA".

14. I know a lot about water resource systems models.
15. I do not know much about hydrologic models.
16. I do not know much about the model know as "HEC HMS."
17. I know a lot about the software known as "STELLA."
18. Part C: Beliefs about models
19. Water resource systems models are useful tools.
20. Hydrologic models are useful tools.
21. The water resource systems model known as "HEC HMS" is a useful tool.
22. The software known as "STELLA" is not a useful tool.
23. Water resource systems models are accurate tools.
24. Hydrologic models are accurate tools.
25. The water resource systems model known as "HEC HMS" is an accurate tool.
26. The software known as "STELLA" is not an accurate tool.
27. We should have more water resource systems models in my river basin.
28. We should use more water resource systems models in my river basin.
29. We should have more hydrologic models in my river basin.
30. We should use more hydrologic models in my river basin.
31. The water resource systems models actually used in the Sonora River Basin are not useful.
32. The hydrologic models actually used in the Sonora River Basin are not useful.
33. Water resource systems models can predict the impacts of climate change.
34. Hydrologic models can predict the impacts of climate change.
35. I do not want to have more training in the use of water resource systems models.
36. I do not want to have more training in the use of hydrologic models.

Part D: Beliefs about water quantity problems, causes, and solutions

1. The Sonora River Basin has sufficient water to satisfy the basic needs of everyone in the basin.
2. More hydrologic studies that help us understand the operation of the basin will help to resolve the problem.
3. Water demand exceeds the available supply in the Sonora River-basin.
4. The water demand DOES NOT exceed the qauntity of water that is available in the Sonora River basin at this moment, but it will in the future.
5. The lack of rain causes the lack of water in the Sonora River basin.
6. Agricultural waste water use causes the lack of available water in the Sonora River basin.
7. Domestic wastewater causes the lack of availability of water in the Sonora River Basin.
8. Better infrastructure WILL NOT help to resolve the problem of lack of water in the Sonora River basin.
9. We DO NOT have adequate infrastructure to distribute the available water in the Sonora River basin.

10. We DO NOT have adequate infrastructure to gather/collect the available water in the Sonora River basin.
11. More efficient use of water could help us to resolve the water quantity problem in the Sonora River basin.

Part E: Impacts from water quantity problems

1. There is excessive exploitation of underground water in the Sonora River basin.
2. The lack of water causes ecological problems.
3. The lack of water hurts the agricultural industry in our region.
4. The lack of water hurts the manufacturing industry in our region.
5. The lack of water reduces population growth in our region.
6. The lack of water reduces economic growth in our region.
7. There is NOT an excessive exploitation of water in the Sonora River basin.
8. Part F: Social impacts from water decisions
9. When there are conflicts, the water should be assigned to whoever will create the maximum benefit for all.
10. When there are conflicts, the water should be assigned to whoever has the greatest need.
11. When we have conflicts between domestic use of water and the use of water for agricultural use, the priority should be given to the domestic uses.
12. When we have conflicts between industrial use of water and the use of water for agricultural use, the priority should be given to the industrial uses.
13. When we have conflicts between industrial use of water and the use of water for domestic use, the priority should be given to the industrial uses.
14. In general, sometimes it is necessary to assign more water to some and less to others.
15. A decision to assign water needs to be fair for everyone.
16. In our region, the decisions to assign water are fair.

Part F: Social impacts from water decisions

1. When there are conflicts, the water should be assigned to whoever will create the maximum benefit for all.
2. When there are conflicts, the water should be assigned to whoever has the greatest need.
3. When we have conflicts between domestic use of water and the use of water for agricultural use, the priority should be given to the domestic uses.
4. When we have conflicts between industrial use of water and the use of water for agricultural use, the priority should be given to the industrial uses.
5. When we have conflicts between industrial use of water and the use of water for domestic use, the priority should be given to the industrial uses.
6. In general, sometimes it is necessary to assign more water to some and less to others.

7. A decision to assign water needs to be fair for everyone.
8. our region, the decisions to assign water are fair.

Part G: Climate change related beliefs

1. The climate is NOT changing.
2. I am familiar with the term climate change.
3. I believe that the Sonora River basin is prepared for the impacts from climate change.
4. Climate change will NOT affect Sonora in the future.
5. Climate change has already affected the Sonora River basin.
6. In the future, more serious floods will occur in the Sonora River basin due to climate change
7. The cause of climate change is anthropogenic (the result of human activities).
8. The cause of climate change is natural.
9. The protection of the atmosphere is a high priority.
10. In the future, there will be more serious droughts in the Sonora River basin due to climate change.
11. Climate change is going to create enormous problems for us in Mexico.
12. In the Sonora River basin, the infrastructure is already efficient to meet the challenge of climate change.

Part H: Evaluation of the process

1. In general, the presentations during the workshops were incomprehensible.
2. In general, the activities were understandable.
3. Participants did not pay attention to the ideas of the rest of the participants.
4. Participants were respectful of the ideas of the rest of the participants.
5. I didn't understand the views of the other participants about water.
6. The pace of the workshops was good (things were not explained too rapidly).
7. The pace of the workshops did not help me to understand how the models work.
8. The pace of the workshops helped me to understand the basis of the models.
9. The locations of the workshops were inconvenient.
10. The locations of the workshops were uncomfortable.
11. The hands-on aspects that were used with the models on my computer were understandable.
12. The hands-on aspects that were used with the models on my computer were useful.

Part I: Results of the workshops

1. I did not contribute to the final version of "STELLA" that was produced in these workshops.

2. My opinions were included in the final version of "STELLA" that was produced in these workshops.
3. I did not contribute to the final version of "HEC HMS" that was produced in these workshops.
4. I have confidence in the final version of "STELLA" that was produced in these workshops.
5. I do not have confidence in the final version of "HEC HMS" that was produced in these workshops.
6. I am satisfied with the final version of the model "HEC HMS" that was produced in these workshops.
7. I am satisfied with the final version of the model "STELLA" that was produced in these workshops.
8. In this workshop, I learned a lot about hydrologic models.
9. In this workshop, I learned a lot about water resource systems models.
10. It was beneficial for me to attend these workshops.
11. The workshops are not worthwhile for others.
12. The scenarios in the last workshop included components that I considered important.

Post-survey questions (Spanish)

Parte B: Creencias sobre capacidad para usar y comprender modelos.

1. Comprendo la diferencia entre modelos de sistemas de recursos del agua y modelos hidrológicos.
2. En general, no comprendo la base de los modelos de sistemas de recursos del agua.
3. En general, comprendo la base de los modelos hidrológicos.
4. No comprendo la base del modelo conocido como "HEC HMS.”
5. Comprendo la base del software conocido como "STELLA.”
6. En general, no comprendo cómo funcionan los modelos de sistemas de recursos del agua.
7. En general, comprendo cómo funcionan los modelos hidrológicos.
8. No comprendo cómo funciona del modelo conocido como "HEC HMS.”
9. Comprendo cómo funciona el software conocido como "STELLA.”
10. En general, me siento capaz de poder trabajar con modelos de sistemas de recursos del agua.
11. En general, me siento capaz de poder trabajar con modelos hidrológicos.
12. Me siento capaz de poder trabajar con el modelo conocido como "HEC HMS."
13. No me siento capaz de poder trabajar con el software conocido como "STELLA.”
14. Sé mucho de los modelos de sistemas de recursos del agua.
15. No sé mucho de los modelos hidrológicos.
16. No sé mucho del modelo conocido como "HEC HMS."
17. Sé mucho del software conocido como "STELLA.”

Parte C: Creencias sobre modelos.

1. En general, los modelos de sistemas de recursos del agua son herramientas útiles.
2. En general, los modelos hidrológicos son herramientas útiles.
3. El modelo de sistemas de recursos del agua conocido como "HEC HMS" es una herramienta útil.
4. El software conocido como "STELLA" no es una herramienta útil.
5. En general, modelos de sistemas de recursos del agua son herramientas exactas.
6. En general, modelos hidrológicos son herramientas exactas.
7. El modelo de sistemas de recursos del agua conocido como "HEC HMS" es una herramienta exacta.
8. El software conocido como "STELLA" no es una herramienta exacta.
9. Deberíamos tener más modelos de sistemas de recursos del agua en mi cuenca.
10. Debemos usar más modelos de sistemas de recursos del agua en mi cuenca.
11. Deberíamos tener más modelos hidrológicos en mi cuenca.
12. Debemos usar más modelos hidrológicos en mi cuenca.
13. Los modelos de sistemas de recursos del agua utilizados actualmente en la cuenca del Río Sonora no son útiles.
14. Los modelos hidrológicos utilizados actualmente en la cuenca del Río Sonora no son útiles.
15. Los modelos de sistemas de recursos del agua pueden predecir los impactos del cambio climático.
16. Los modelos hidrológicos pueden predecir los impactos del cambio climático.
17. No quiero tener más entrenamiento en el uso de modelos de sistemas de recursos del agua.
18. No quiero tener más entrenamiento en el uso de modelos hidrológicos.

Parte D: Creencias sobre los problemas de cantidad de agua: causas y soluciones.

1. La cuenca del Río Sonora tiene suficiente agua para satisfacer las necesidades básicas de todos en la cuenca.
2. Más estudios hidrológicos que nos ayuden a entender el funcionamiento de la cuenca ayudarán a resolver el problema.
3. La demanda de agua excede la cantidad de agua que se tiene disponible en la cuenca del Río Sonora.
4. La demanda de agua no excede la cantidad de agua que se tiene disponible en la cuenca del Río Sonora en este momento, pero lo hará en el futuro.
5. La falta de lluvia ocasiona la falta de agua disponible en la cuenca del Río Sonora.
6. El desperdicio de agua en el uso agrícola ocasiona la falta de disponibilidad de agua en la cuenca del Río Sonora.
7. El desperdicio de agua en el uso doméstico ocasiona la falta de disponibilidad de agua la cuenca del Río Sonora.
8. Mejor infraestructura no ayudará a resolver el problema de falta de agua en la cuenca del Río Sonora.
9. No tenemos la infraestructura adecuada para distribuir el agua disponible en la cuenca del Río Sonora.
10. No tenemos la infraestructura adecuada para recolectar el agua disponible en la cuenca del Río Sonora.
11. El uso más eficiente del agua nos ayudaría a resolver el problema de la cantidad de agua en la cuenca del Río Sonora.

Parte E: Los impactos de problemas de cantidad del agua.

1. Existe una explotación excesiva del agua subterránea en la cuenca del Río Sonora.
2. La falta de agua ocasiona problemas ecológicos.
3. La falta de agua perjudica a la industria agrícola en nuestra región.
4. La falta de agua perjudica a la industria manufacturera en nuestra región.
5. La falta de agua reduce el crecimiento de la población en nuestra región.
6. La falta de agua reduce el desarrollo económico en nuestra región.
7. No existe una explotación excesiva del agua de la cuenca del Río Sonora.

Parte F: Los impactos sociales de decisiones sobre agua.

1. Cuando hay conflictos, el agua debe ser asignada a quien la utilice para crear el mayor beneficio para todos.
2. Cuando hay conflictos, el agua debe ser asignada a quiénes tengan la mayor necesidad.
3. Cuando tenemos conflictos entre el uso doméstico del agua y el uso de agua para la agricultura, se debe dar prioridad al uso doméstico del agua.

4. Cuando tenemos conflictos entre el uso industrial del agua y el uso de agua para la agricultura, se debe dar prioridad al uso industrial del agua.
5. Cuando tenemos conflictos entre el uso industrial del agua y el uso doméstico, se debe dar prioridad al uso industrial del agua.
6. En general, a veces es necesario tomar la decisión que asignar más agua a unos y menos a otros.
7. Una decisión para asignar agua necesita ser justa para todos.
8. En nuestra región, las decisiones asignando agua son justas.

Parte G: Creencias relacionadas al cambio climático

1. El clima no está cambiando.
2. Estoy familiarizado con el término “cambio climático".
3. Creo que la cuenca del Río Sonora está preparada para los impactos del cambio climático.
4. El cambio climático no afectará a Sonora en el futuro.
5. El cambio climático ya afecta a la cuenca del Río Sonora.
6. En el futuro inundaciones más serias ocurrirán en la cuenca del Río Sonora debido al cambio climático.
7. La causa del cambio climático es antropogénica (resultado de actividades humanas).
8. La causa del cambio climático es natural.
9. La protección del medio ambiente es de alta prioridad.
10. En el futuro se producirán sequías más serias en la cuenca del Río Sonora debido al cambio climático.
11. El cambio climático va a crear problemas enormes para nosotros en México.
12. En la cuenca del Río Sonora, la infraestructura ya es suficiente para afrontar el reto del cambio climático.

Parte H: Evaluación del proceso

1. En general, las presentaciones durante los talleres fueron incomprensibles.
2. En general, las actividades fueron comprensibles.
3. Los participantes no pusieron atención a las ideas de los demás participantes.
4. Los participantes fueron respetuosos de las ideas de los demás participantes.
5. No comprendí las opiniones de los demás participantes sobre el agua.
6. El ritmo de los talleres fue bueno (las cosas no fueron explicadas rápidamente).
7. El ritmo de los talleres no me ayudo a comprender cómo funcionan los modelos.
8. El ritmo de los talleres me ayudo a comprender la base de los modelos.
9. Las ubicaciones fueron inconvenientes para los talleres.
10. Las ubicaciones fueron incómodas para los talleres.
11. Los aspectos manuales que utilize con los modelos en mi computadora fueron comprensibles.

12. Los aspectos manuales que utilize con los modelos en mi computadora fueron útiles.

Parte I: Resultados de los talleres

1. No contribuí a la versión final de “STELLA” que se produjo en éstos talleres.
2. Mis opiniones fueron incluídas en la versión final de “STELLA” que se produjo en estos talleres.
3. No contribuí a la versión final de “HEC HMS” que se produjo en estos talleres.
4. Tengo confianza en la versión final de “STELLA” que se produjo en éstos talleres.
5. No tengo confianza en la versión final de “HEC HMS” que se produjo en éstos talleres.
6. Estoy satisfecho(a) con la versión final del modelo “HEC HMS” que se produjo en éstos talleres.
7. Estoy insatisfecho(a) con la versión final del modelo “STELLA” que se produjo en éstos talleres.
8. En éstos talleres aprendí mucho sobre los modelos hidrológicos.
9. En éstos talleres aprendí poco sobre los modelos de sistemas de recursos de agua.
10. Me beneficie al asistir éstos talleres.
11. Éstos talleres no valen la pena para otros.
12. Los escenarios del último taller incluyeron componentes que yo considero importantes.